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STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
DIVISION OF RESOURCES PLANNING

BULLETIN NO. 90

CLEAR LAKE-CACHE CREEK
BASIN INVESTIGATION

PRELIMINARY
SUBJECT TO REVISION

EDMUND G. BROWN
Governor



WILLIAM E. WARNE
Director of Water Resources

MARCH 1961

Cache Creek
Document

235

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WILLIAM E. WARNE
DIRECTOR

EDMUND G. BROWN
GOVERNOR

ADDRESS REPLY TO
P. O. BOX 358 SACRAMENTO 2
1120 N STREET HICKORY 5-4711



STATE OF CALIFORNIA
Department of Water Resources
SACRAMENTO

March 15, 1961

Honorable Edmund G. Brown, Governor,
and Members of the Legislature
of the State of California

Gentlemen:

I have the honor to transmit herewith Bulletin No. 90 of the Department of Water Resources, entitled "Clear Lake-Cache Creek Basin Investigation", as authorized by Item 257 of the Budget Act of 1958 and Item 262 of the Budget Act of 1959.

Bulletin No. 90 presents the Wilson Valley Project as a comprehensive plan which would develop the water resources of the Clear Lake-Cache Creek Basin for all beneficial uses and purposes. It recommends construction of the project by local interests, with financial assistance from the Federal Government and the State of California.

Sincerely yours,

A handwritten signature in cursive script that reads "William E. Warne".

Director

ACKNOWLEDGMENT

Valuable data and assistance during this investigation have been contributed by agencies of the Federal Government, counties, cities, public districts, and by private individuals and companies. This cooperation is gratefully acknowledged.

Special mention is made of the helpful cooperation of the following:

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- County of Lake
- County of Yolo
- City of Lakeport
- City of Woodland
- Lake County Flood Control and Water
Conservation District
- Yolo County Flood Control and Water
Conservation District
- Yolo County Farm Advisor
- Clear Lake Water Company
- Pacific Gas and Electric Company

ORGANIZATION

STATE DEPARTMENT OF WATER RESOURCES DIVISION OF RESOURCES PLANNING

William E. Warne Director of Water Resources
James F. Wright Chief Deputy Director
B. Abbott Goldberg Deputy Director-Contracts
Reginald C. Price Deputy Director-Policy
Alfred R. Golzé Chief Engineer, Department of
Water Resources
William L. Berry Division Engineer
Division of Resources Planning
John M. Haley Chief, Project Development Branch

This investigation was conducted
under the direction of

William L. Horn Chief, Local Project Section

and

reviewed and edited under the direction of

Albert J. Dolcini Chief, California Aqueduct Section

Technical studies and preparation
of the bulletin were under the supervision of

M. Guy Fairchild Supervising Engineer, Water Resources
Stuart T. Pyle Senior Engineer, Water Resources

Assistance was furnished by

Richard E. Slyfield Senior Engineer, Water Resources
Orville Abbott Senior Engineer, Water Resources
David M. Hill Senior Engineering Geologist
Arthur B. Arnold Senior Engineering Geologist
Virgil E. Whiteley Senior Economist
Robert Macklin Fisheries Management Supervisor
Henry A. Hjersman Recreation Planner
Freeman H. Beach Assistant Civil Engineer
Kenneth R. Henneman Assistant Civil Engineer
Ned R. Peterson Assistant Civil Engineer
Donald K. Cole Assistant Economist
Perry Y. Amimoto Assistant Engineering Geologist
John L. James Supervisor of Drafting Services

-----O-----

Porter A. Towner Chief Counsel
Paul L. Barnes Chief, Division of Administration
Isabel C. Nessler Coordinator of Reports

ORGANIZATION
CALIFORNIA WATER COMMISSION

WILLIAM H. JENNINGS, Acting Chairman, La Mesa

JOHN W. BRYANT, Riverside

JOHN P. BUNKER, Gustine

IRA J. CHRISMAN, Visalia

GEORGE C. FLEHARTY, Redding

JOHN J. KING, Petaluma

SAMUEL B. MORRIS, Los Angeles

RALPH M. BRODY, Fresno

-----O-----

GEORGE B. GLEASON
Chief Engineer

WILLIAM M. CARAH
Executive Secretary

CHAPTER I. INTRODUCTION

The residents of the Clear Lake-Cache Creek Basin have shown increasing concern in recent years regarding the adequacy of presently developed water supplies and the ever-present threat of damaging floods. As a result of this concern, both Lake and Yolo Counties have independently entered into cooperative agreements with the State for investigations of water problems and formulation of plans for their solution. Under terms of a cooperative agreement with Lake County, entered into in 1948, the Division of Water Resources undertook a study of Big Valley and Scott Valley, and the Upper Lake area, within the Clear Lake Basin. Results of this investigation were reported in Department of Water Resources Bulletin No. 14, "Lake County Investigation", published in July, 1957.

Under a similar agreement with Yolo County, entered into in 1954, the Division of Water Resources conducted a study of the possibilities of developing the waters of Cache Creek for use in Yolo County. Two bulletins on this investigation were published; State Water Resources Board "Interim Report, Cache Creek Investigation", in March, 1955, and Department of Water Resources Bulletin No. 20, "Comparison of Alternative Wilson Valley and Guinda Projects on Cache Creek", in April, 1958. Following the publication of the first of these bulletins, the 1956 Legislature added Chapter 2, Article 2, Section 12663 to the Water Code, which section is quoted as follows:

"12663. The plan of improvement for flood control and water conservation on Cache Creek, including Clear Lake, in Lake and Yolo Counties, is hereby adopted and

authorized generally in accordance with the recommendations relating thereto contained in the report dated March 4, 1955 (Reports of State Water Resources Board), at an estimated cost to the State of two million five hundred thousand dollars (\$2,500,000) for lands, easements and rights of way, including all utility and highway relocations, necessary for the construction of said project. No funds shall be expended on planning or constructing a dam at the Guinda site below Rumsey on Cache Creek until the Wilson Valley area has been completely investigated and studied and determined by the department not to have comparable engineering and economic feasibility as compared to the Guinda site as recommended in said report."

Following the publication of Bulletin No. 20, the 1959 Legislature amended Section 12663 to read as follows:

"12663. The plan of improvement for flood control and water conservation on Cache Creek, including Clear Lake, in Lake and Yolo Counties, is hereby adopted and authorized generally in accordance with the recommendations relating thereto contained in the interim report of the Department of Water Resources entitled, "Comparison of Alternative Wilson Valley and Guinda Projects on Cache Creek", dated April, 1958, at an estimated cost to the State of such sum as may be appropriated for state cooperation by the Legislature upon the recommendation and advice of the department."

Authorization for Investigation

The water resource investigations conducted under the cited cooperative agreements with Lake and Yolo Counties were limited to studies of specific problems or to studies of specific, but limited, areas of the basin. There has been a need, therefore, for study of the water problems of the entire Clear Lake-Cache Creek Basin, and the formulation of a comprehensive plan for the integrated development of the water resources of the basin. The current investigation was conducted to satisfy this need and it was initiated in July, 1958, under the authority granted to the department by Section 12616 of the Water Code.

It has been financed by the State under the California Water Planning Program, which was funded during the two-year investigational period by Item 257 of the Budget Act of 1958 and by Item 262 of the Budget Act of 1959.

Objective and Scope of Investigation

The Clear Lake-Cache Creek Basin Investigation has as its objective the formulation of a comprehensive plan for development of the water resources of the Clear Lake-Cache Creek Basin for conservation, flood control, recreation, and fish and wildlife. Water development facilities are needed in the basin to satisfy the increasing demand for irrigation, as well as to provide flood control to the lands adjacent to Clear Lake and the lower reaches of Cache Creek. Through reduction in fluctuation of the water level in Clear Lake, considerable expansion of existing recreational facilities at the lake could take place.

Field work and office studies commenced in July, 1958, and continued into the fall of 1960. Hydrologic data were reviewed and analyzed for the purpose of estimating the surface and ground water supplies available for development in the Clear Lake-Cache Creek Basin. A review was made of the geologic information obtained in 1955 and 1956 from foundation drilling operations conducted at two sites for the proposed Wilson Valley Dam. Also, a review and compilation was made of the reconnaissance geologic studies that had been conducted at the Kelseyville Dam site on Kelsey Creek, Pitney Ridge Dam site on Middle Creek, and Scotts Valley Dam site on Scott Creek in connection with the Lake County Investigation; and at Excelsior Dam site on Copsey Creek, Indian

Valley Dam site on North Fork Cache Creek, and Blue Ridge Dam on Cache Creek in connection with the formulation of The California Water Plan.

Studies of the proposed Wilson Valley Project were designed to result in a determination of engineering feasibility, economic justification, and financial feasibility. Similar studies of a more preliminary nature were made for an alternative to the Wilson Valley Project with respect to provision of supplemental water in the Cache Creek area. This alternative involved a combination of local storage and a diversion from the Sacramento River. Studies of the other projects described herein were generally limited to a review and re-analysis of existing data.

Related Investigations and Reports

Several prior investigations and reports of the Department of Water Resources and its predecessor agency, the Division of Water Resources, were reviewed in connection with Clear Lake-Cache Creek Investigation, and pertinent data were utilized where appropriate. Those investigations of particular pertinence to this bulletin are briefly described in the following paragraphs.

State-Wide Water Resources Investigation

In recognition of the growing statewide water problems, the Legislature by Chapter 1541, Statutes of 1947, authorized the State-wide Water Resources Investigation. This investigation was conducted by the Division of Water Resources, under the direction of the State Water Resources Board. Funds were

appropriated annually by the Legislature over a 10-year period for the completion of this important program of study. Results of the investigation were published in three bulletins. State Water Resources Board Bulletin No. 1, "Water Resources of California", published in 1951, contains a concise compilation of data for the entire State on precipitation, unimpaired stream flow, flood flows and frequencies, and quality of water. Bulletin No. 2, "Water Utilization and Requirements of California", published in 1955, sets forth estimates of present and forecasts of probable ultimate water requirements throughout the State based, in general, on the capabilities of the land to support further development.

During the latter portion of the State-wide Water Resources Investigation, intensive effort was devoted to the equating of California's water resources and ultimate water requirements in the formulation of The California Water Plan which was published in Department of Water Resources Bulletin No. 3, "The California Water Plan", May, 1957. The California Water Plan is a comprehensive master plan for the full development of the water resources of the State to meet present and future needs for all beneficial purposes in all parts of the State, insofar as practicable. The Legislature, by enactment of Chapter 2053, Statutes of 1959, adopted The California Water Plan as a general guide for the orderly and coordinated development and utilization of the water resources of the State.

Northeastern Counties Investigation

The Northeastern Counties Investigation, which was initiated in 1954, involved an evaluation of the potential

development of the natural resources and the determination of the ultimate water needs of the 15 northeastern counties, including the Counties of Lake and Yolo. A preliminary report on the investigation was published in December, 1957, as Department of Water Resources Bulletin No. 58, "Northeastern Counties Investigation". A final report on the investigation was published in 1960.

Putah Creek Cone Investigation

The Putah Creek Cone Investigation was initiated in 1951 pursuant to Chapter 1748, Statutes of 1951. The investigation involved a study of surface and underground water supplies of the Putah Creek Cone and adjacent areas, in the Counties of Solano and Yolo, and an evaluation of present and future water requirements and possible sources of supplemental water supplies. Results of the investigation were published in 1955 in a Department of Water Resources bulletin, "Putah Creek Cone Investigation". Inasmuch as the Putah Creek Cone Investigational area extended north of Putah Creek, thus overlapping a portion of the lower Cache Creek Basin, data developed during that investigation were utilized during the current investigation.

Prior Investigations Within Clear Lake-Cache Creek Basin

As previously mentioned, Cache Creek and the Clear Lake area have been investigated by the department and its predecessor agency under terms of cooperative agreements between local interests and the State. Results of the Cache Creek Investigation, involving a cooperative study of the possibilities for developing the waters of Cache Creek for use in Yolo County, were published in two bulletins. A State Water Resources Board bulletin, "Interim

Report Cache Creek Investigation", published in March, 1955, presents information on the possibilities for developing a reservoir at the Guinda site on Cache Creek. Department of Water Resources Bulletin No. 20, "Comparison of Alternative Wilson Valley and Guinda Projects on Cache Creek", published in April, 1958, presents a comparison of features and accomplishments of the alternative projects and recommends the construction of Wilson Valley Reservoir.

Certain portions of Lake County were investigated pursuant to a 1949 agreement between Lake County and the State for a cooperative study of the problems of underground water supplies of Big Valley, Scotts Valley, and the Upper Lake area. State Water Resources Board Bulletin No. 14, "Lake County Investigation", published in July, 1957, presents the results of the investigation, including consideration of surface and ground water supplies, determinations of present and ultimate water utilization and supplemental requirements, and plans for obtaining supplemental water supplies.

Area Under Investigation

The Clear Lake-Cache Creek Basin is located on the eastern slope of the Coast Range in Lake and Yolo Counties. It extends some 80 miles in a northwest-southeast direction, with a maximum width of about 30 miles. The basin embraces an area of about 1,600 square miles, of which about 820 square miles are in Lake County, 100 square miles are in Colusa County, and 680 square miles are in Yolo County. County and basin boundaries are delineated on Plate 1, entitled "Area of Investigation and Hydrologic Units".

percent of the average seasonal rainfall occurs in the months from November through April. Mean seasonal rainfall varies from less than 16 inches in the vicinity of Davis to more than 50 inches in the highlands on the westerly edge of the basin. Winter temperatures seldom fall much below freezing, and temperatures of the warm dry summers frequently exceed 100^o Fahrenheit. The average frost-free period in areas of agricultural development is about 250 days in the Cache Creek area and about 217 days in the Clear Lake area.

For study purposes, and in order to facilitate reference herein, the Clear Lake-Cache Creek Basin has been divided into two major subbasins, designated the "Clear Lake Basin" and the "Cache Creek Basin". The locations of these subbasins are also shown on Plate 1. These designations will be used in reference to the two subbasins throughout the ensuing text.

Clear Lake Basin

The Clear Lake Basin is generally mountainous. It is centered around Clear Lake and contains several large valleys bordering the lake, that are suitable for intensive agricultural development. The major stream systems tributary to Clear Lake are Kelsey, Scott, and Middle Creeks. The communities of Lakeport, Upper Lake, Kelseyville, Nice, Clearlake Highlands, Clearlake Park, and Clearlake Oaks, comprise the principal urban developments. These communities all experience a large influx of recreationists during the summer months. Lakeport, the county seat and largest community, has a permanent population of about 2,000.

Clear Lake is a large shallow natural body of water with an area of about 64 square miles, an elevation of about 1,325 feet, and a maximum depth of about 50 feet. It has been developed and is operated by the Clear Lake Water Company to provide irrigation water to a portion of the Sacramento Valley near Woodland. The lake is operated as stipulated under terms of the Gopcevic Decree. Under this decree the Clear Lake Water Company is permitted to fluctuate the lake between the limits of zero and 7.56 feet on the Rumsey Gage which is located near the edge of the lake at Lakeport. Within these limits, the lake has a storage capacity of about 314,000 acre-feet. A copy of the Gopcevic Decree is included in Appendix A to this bulletin.

Water from Clear Lake flows through an outlet channel and is released into Cache Creek from the Clear Lake Impounding Dam. The outlet channel lacks sufficient carrying capacity to pass the runoff that accumulates in the lake during times of excessive flood inflow from tributary streams. Consequently, during periods of excessive runoff, extensive flood damage occurs to lands and improvements adjacent to the lake. Under the terms of the Bemmerly Decree, which resulted from litigation brought by downstream interests, the outlet channel from Clear Lake cannot be enlarged to pass flood waters from the lake at an increased rate of flow. This litigation resulted from the concern of downstream interests about additional flooding of their property, should additional water be added to the flow of Cache Creek during flood stage. A copy of the Bemmerly Decree is also included in Appendix A to this bulletin.

The principal agricultural areas of the Clear Lake Basin include Big Valley, Scott Valley, and the Upper Lake area. Formerly, the major portion of the tillable land in these areas was devoted to the production of dry-farmed crops. In recent years, however, irrigation has been initiated, with resultant substantial increase in crop yields. Principal irrigated crops include walnuts, pears, alfalfa, and permanent pasture. Water supplies for farming operations are obtained from wells. The dry farming depends upon rainfall, which averages 23 to 30 inches annually.

Industry in the Clear Lake Basin is limited and is supported largely by agricultural production. Processing plants for agricultural products are operated during harvest seasons to process fruits, nuts, and vegetables. Large sand and gravel plants are operated near Kelseyville.

Clear Lake receives wide use as a recreational facility. Numerous resorts, motels, fishing piers, and boat ramps are located along its shores. Recreational pursuits include fishing, swimming, and water skiing. It is estimated that the present average annual use for water-associated recreational purposes amounts to about 2,300,000 visitor days. Because the Clear Lake Water Company operates Clear Lake to obtain a water supply for agricultural purposes, the lake is drawn down during the late summer months. During years of low inflow to the lake, this lowering of the lake level is a detriment to the recreational interests. Consequently, any operation of the lake that would tend to stabilize its water surface would enhance the recreational potential of Clear Lake.

Cache Creek Basin

The Cache Creek Basin embraces the portion of the investigational area lying downstream from the community of Rumsey, as shown on Plate 1. The basin includes Capay Valley and a portion of the western Sacramento Valley located on the Cache Creek alluvial fan.

Capay Valley, varying from about one to three miles in width, extends from the mouth of Cache Creek Canyon approximately 16 miles in a southeasterly direction to the edge of the Sacramento Valley. Agriculture, including the production of alfalfa, deciduous orchards, and grain, provides the major source of income. Irrigation water is obtained from diversions from Cache Creek, supplemented by pumping from ground water sources. Dry farming depends upon rainfall, which averages some 26 inches in depth annually. Flood damages occur below Rumsey during periods of high water when the runoff exceeds the channel capacity of Cache Creek.

The Cache Creek alluvial fan extends easterly from the lower end of Capay Valley about 19 miles to the Yolo Bypass. The major portions of the alluvial fan extend south of Cache Creek to Putah Creek. The economic development of this area is based almost entirely on agriculture. Formerly, the major portion of its tillable land was devoted to the production of dry-farmed grains. The development of irrigation has permitted a greater diversification of crops and an increase in production. Principal irrigated crops include alfalfa, rice, peaches, apricots, almonds, sugar beets, and tomatoes. Irrigated permanent pasture provides feed for beef and dairy cattle, and sheep.

Distribution works for delivering the waters of Cache Creek to a large portion of the Cache Creek alluvial fan have been developed by the Clear Lake Water Company. A canal system, including the Capay and Adams Canals, originates at the Capay Diversion Dam about two miles west of the town of Capay, and conveys water along the west, south, and north edges of the Cache Creek Basin. Moore Dam, located on Cache Creek approximately 10 miles downstream from Capay Dam, diverts water into the Moore Canal system for distribution to lands lying west of Woodland. The available water supply includes controlled releases and spill from Clear Lake, together with unregulated flow tributary to Cache Creek occurring downstream from the outlet of the lake.

Local industry in the Cache Creek Basin is supported by agricultural production. Various plants process meat, dehydrate vegetables and fruit, and refine sugar beets. In addition, packing houses and cold storage plants serve the food processing industry. The expansion of highway facilities has kept pace with the agricultural and industrial development of the area. The cities of Woodland, Davis, and Winters are the major centers of urban development.

Organization of Report

Results of the Clear Lake-Cache Creek Basin Investigation are presented in this bulletin in the four ensuing chapters. Chapter II, "Water Supply", discusses factors influencing the availability of water and presents information, based upon records

and estimates, on precipitation, stream flow, ground water hydrology, and mineral quality of both surface and subsurface water resources. Chapter III, "Water Utilization and Requirements", presents data and estimates of present and probable ultimate land use and use of water by various types of culture, and evaluates present and estimates future water requirements and requirements for additionally developed water. It also discusses nonconsumptive water requirements for the important purposes of flood control, recreation, and fish and wildlife.

Chapter IV, "Plans for Water Development", discusses possible plans for providing supplemental water for the Clear Lake Basin, and presents a detailed analysis of the Wilson Valley Project for development of a supplemental water supply for the Cache Creek Basin and flood control and recreational benefits for both the Clear Lake and Cache Creek Basins. It also discusses an alternative development of Cache Creek to be operated coordinately with an importation from the Sacramento River. Chapter V, "Summary of Conclusions, and Recommendations", sets forth the findings of the investigation, together with recommendations developed therefrom.

CHAPTER II. WATER SUPPLY

The major portion of the water resources of the Clear Lake-Cache Creek Basin originates as rainfall in the upper portions of the basin. Snowfall is of insignificant importance as a source of water supply because of its infrequency of occurrence and short duration. Runoff, being a direct function of rainfall, reflects the duration and intensity of storms during the winter period. The seasonal runoff pattern is varied, with large flows occurring during the winter and early spring months, and meager flows occurring during the summer and fall months. Of far greater significance with respect to further conservation, however, is the wide fluctuation of runoff from year to year.

Ground water in the alluvial basins, replenished by surface runoff, is the principal source of water for irrigation and municipal uses in the Clear Lake-Cache Creek Basin. Outflow from the Clear Lake Basin, regulated by the Clear Lake Impounding Dam, meets the bulk of the remaining water requirements in the downstream Cache Creek Basin.

In the ensuing discussion of the factors of water supply in this chapter, certain periods were chosen for detailed analysis of the hydrology of the Clear Lake-Cache Creek Basin. These periods, their definition, and the reason for their selection are set forth in the following paragraphs, and they will be so used throughout this bulletin.

Mean Period--A period chosen to represent conditions of water supply and climate over a long series of years. In studies conducted during the Clear Lake-Cache Creek Basin

Investigation, the 50-year period from 1905-06 through 1954-55 was selected as representing mean conditions of water supply and climate. Both mean annual precipitation and mean annual runoff were computed for this 50-year period.

Study Period--A period chosen for detailed hydrologic analysis, particularly with respect to evaluation of the present and potential yield of ground water resources in the Cache Creek Basin. The 6-year period from 1953-54 through 1958-59 was selected for hydrologic analysis during the current investigation because of the adequate coverage of records of items of water supply and water disposal. In comparing the 6-year study period with the mean period, it should be recognized that annual averages of both precipitation and runoff were higher during the study period than during the mean period. This is due to the occurrence of two very wet years, during 1956 and 1958, in which were experienced two of the highest floods of record. However, as will be discussed later in this chapter, the method utilized in evaluating the hydrology minimizes the significance of the greater wetness of the study period.

Precipitation

The Clear Lake-Cache Creek Basin lies within the area traversed by the southern portion of storms which sweep inland from the North Pacific during winter and spring months. Rainfall resulting from these storms is moderately heavy and generally increases with an increase in land elevation. This is illustrated by Plate 2, entitled "Lines of Equal Mean Seasonal Precipitation",

which indicates a general increase in precipitation from the valley floor in the easterly portion of the basin near Davis to the highlands in the westerly portion near Clear Lake.

Precipitation Stations and Records

There are 85 precipitation stations in or adjacent to the Clear Lake-Cache Creek Basin with continuous records of 10 years duration or longer. These stations are fairly well distributed areally, and their records are sufficient to provide an adequate pattern of precipitation. Most of the records have been published in previous bulletins of the Department of Water Resources and the U. S. Weather Bureau. Locations of the precipitation stations within the area of investigation are shown on Plate 2, and they are referenced on that plate by U. S. Weather Bureau identification number. These stations are listed in Table 1, together with their elevations, periods and sources of record, and values of mean, maximum, and minimum seasonal precipitation. In those cases where it was necessary, precipitation records were extended to cover the mean period by direct correlation with records of nearby stations covering the longer period.

TABLE 1
RECORDED MAXIMUM, MINIMUM AND ESTIMATED MEAN ANNUAL
PRECIPITATION AT STATIONS WITH MORE THAN TEN YEARS OF RECORD
IN OR ADJACENT TO THE CLEAR LAKE-CACHE CREEK BASIN

Location: number	Township, range, and section MDB&M	Station	Elevation, in feet	Period of record	Source of record	Estimated or recorded mean seasonal precipi- tation, in inches	Recorded maximum and minimum season- al precipitation Season : In inches
A90039	9N/6W-1	Aetna Springs	800	1924-38	Private	34.59	1937-38 1930-31 58.02 17.96
A00250	13N/2W-29	Arbuckle 5 SSW	360	1940 to date	Private	15.89	1940-41 1956-57 33.64 10.03
A80527	15N/8W-2	Bartlett Springs	2,100	1933-38 1942-48	Private USWB ^a	43.17	1937-38 1946-47 80.61 29.75
A81112	11N/3W-36	Brooks Farnham	350	1921 to date	USWB ^a	20.18	1940-41 1923-24 44.86 9.61
A91154	6N/2W-1	Bucktown	280	1918-53	Private	26.17	1940-41 1938-39 54.35 11.15
E31312	9N/7W-36	Calistoga	365	1873 to 1918-40 1940 to date	USWB ^a SPRR ^b USWB ^a	33.35	1889-90 1923-24 67.51 12.16
F91311	8N/7W-16	Calistoga 4 SW	750	1950 to date	SCPCWCD ^c	43.74	1957-58 1958-59 72.59 25.84
F91318	16N/12W-20	Calpella	900	1922-42	USED ^d	36.69	1935-36 1923-24 56.00 18.00
A01499	10N/2W-15	Capay 1 W	250	1945 to date	Private	20.35	1957-58 1956-57 34.62 12.63
A81500	10N/2W-20	Capay 4 W	290	1889 to date	Private	21.92	1940-41 1919-20* 47.37 9.92*
F91838	11N/10W-29	Cloverdale 3 SSE	320	1877 to date	USWB ^a	40.08	1940-41 1923-24 68.90 15.75
F91840	11N/12W-17	Cloverdale 11 W	1,750	1939 to date	USWB ^a	57.47	1957-58 1946-47 102.06 43.07
A91880	11N/8W-10	Cobb	2,520	1923 to date	Private	60.30	1957-58 1923-24 115.37 22.38
A02274	11N/2E-21	Dan Best Ranch	45	1941 to date	Private	15.32	1957-58 1956-57 25.94 10.59
A02294	08N/2E-16	Davis Agriculture College	51	1871 to date	USWB ^a	16.37	1889-90 1876-77 37.41 5.12
A02293	8N/3E-7	Davis Nursery	28	1931-54 1959 --	CDP ^e	16.66	1940-41 1938-39 32.06 7.65
A02298	8N/2E-18	Davis 2 WSW	61	1918-19 1924 to date	Private	16.09	1940-41 1938-39 31.10 6.98
A02299	9N/2E-33	Davis 2NNW	47	1926 to date	Private	17.44	1940-41 1938-39 30.74 7.06
E32433	8N/6W-18	Diamond Mountain	1,800	1949 to date	SCPCWCD ^c	47.22	1957-58 1958-59 78.60 29.56
B92451	7N/1E-23	Dixon	79	1924 to date	Private	16.85	1940-41 1938-39 35.11 7.06
A02568	12N/1W-15	Dunnigan	65	1877-1918 1931 to date	USWB ^a	15.28	1889-90 1938-39 37.45 6.32
A02569	12N/1W-17	Dunnigan-Powers Ranch	104	1929 to date	Private	15.56	1940-41 1938-39 33.84 6.40
A02570	12N/1W-6	Dunnigan 3NW	160	1937 to 1958	Private	16.67	1940-41 1938-39 35.72 7.45
A02573	12N/2W-26	Dunnigan 5WSW	310	1915-1940	Private	17.30	1937-38 1938-39 28.74 6.68
A32640	17N/6W-3	East Park Reservoir	1,205	1910 to date	USWB ^a	17.82	1940-41 1938-39 42.43 5.64

TABLE 1 (continued)

RECORDED MAXIMUM, MINIMUM AND ESTIMATED MEAN ANNUAL
PRECIPITATION AT STATIONS WITH MORE THAN TEN YEARS OF RECORD
IN OR ADJACENT TO THE CLEAR LAKE-CACHE CREEK BASIN

Location: number :	Township, range, and section :	Station	Elevation, in feet :	Period of record :	Source of record :	Estimated or recorded mean seasonal precipi- tation, in inches :	Recorded maximum and minimum season- al precipitation Season : In inches
A02880	10N/2W-34	Esparto 3WSW	350	1925-39 1947-58	Private	19.51	1937-38 36.77 1938-39 10.00
A02881	10N/1W-19	Esparto	190	1915-38 1948 to date	Private	17.07	1957-58 32.85 1930-31 8.31
A83687	11N/3W-4	Guinda	360	1896-1939 1947 to date	USWB ^a and Private	20.56	1957-58 38.52 1923-24 9.92
A93891	10N/8W-1	Helen Mine	2,760	1900-22	USWB ^a	82.66	1908-09 126.29 1917-18 49.38
F93875	9N/9W-19	Hesldsburg	101	1877 to date	USWB ^a	38.16	1940-41 72.55 1885-86 16.35
A84010	12N/8W-35	Hobergs	2,980	1930 to date	USWB ^a	50.80	1937-38 112.50 1938-39 30.09
A84097	14N/10W-32	Hopland 8NE	2,510	1939 to date	USWB ^a	37.82	1940-41 67.38 1946-47 24.72
F94099	13N/11W-20	Hopland 2SE	500	1946 to date	SCFCWCD ^c	33.84	1957-58 61.10 1946-47 24.31
A04390	13N/1W-22	Johns School	60	1949 to date		14.70	1957-58 29.10 1956-57 4.67
A04449	11N/3E-20	Karnsk	23	1940 to date	Reclama- tion District #1500	16.92	(Records not in our files)
F94480	9N/7W-9	Kellogg	1,800	1936 to date	SCFCWCD ^c and USWB ^a	41.62	1940-41 73.94 1938-39 27.05
A84488	13N/9W-14	Kelseyville	1,385	1931 to date	USWB ^a	24.72	1957-58 42.68 1938-39 11.77
A84494	13N/9W-2	Kelseyville 2N	1,345	1935- 1953	UC ^f	23.41	1940-41 41.49 1938-39 13.18
A04591	11N/2E-14	Knights Landing	35	1878- 1958	USWB ^a	16.39	1889-90 33.29 1938-39 6.64
A84600	14N/8W-29	Kono Tayee	1,325	1874- 1884 1892- 1904	USWB ^a	23.19	1877-78 37.33 1876-77 12.08
P64697	18N/10W-14	Lake Pillsbury	1,900	1924- 1937 1940- 1950	USWB ^a	39.85	1940-41 62.55 1930-31 28.37
A84701	14N/10W-24	Lakeport	1,343	1905 to date	USWB ^a	27.41	1957-58 50.30 1930-31 12.69
A84700	14N/10W-14	Lakeport 2NW	1,475	1929 to date	Private	31.27	1940-41 56.64 1930-31 14.39
A84702	14N/10W-22	Lakeport 3W	1,475	1932 to date	Private	34.31	1957-58 64.30 1938-39 20.93
A84880	15N/5W-17	Leesville Keegan Ranch	1,340	1950 to date	Private	22.91	1957-58 44.33 1958-59 14.98
A85161	12N/7W-4	Lower Lake 1W	1,450	1935 to date	Private	27.16	1957-58 68.60 1938-39 11.13
F95220	10N/9W-23	Lytton 4NE	500	1938 to date	SCFCWCD ^c	36.03	1957-58 73.10 1938-39 18.91

TABLE 1 (continued)

RECORDED MAXIMUM, MINIMUM AND ESTIMATED MEAN ANNUAL
PRECIPITATION AT STATIONS WITH MORE THAN TEN YEARS OF RECORD
IN OR ADJACENT TO THE CLEAR LAKE-CACHE CREEK BASIN

Location: number	Township, range, and section MDB&M	Station	Elevation, in feet	Period of record	Source of record	Estimated or recorded mean seasonal precipi- tation, in inches	Recorded maximum and minimum season- al precipitation Season : In inches
A05234	10N/1W-33	Madison 1SW	175	1940-1954	Private	16.49	1940-41 1946-47 36.20 10.09
A05237	9N/1W-16	Madison 4SSE	70	1898-1939	Private	17.68	1913-14 1912-13 30.61 8.58
A95598	10N/7W-3	Middletown	1,122	1938 to date	USWB ^a	44.43	1955-56 1958-59 76.98 29.68
A95976	9N/7W-2	Mt. St. Helena	2,300	1901-1912	USWB ^a	54.60	1906-07 1911-12 79.56 32.44
F66717	17N/9W-21	Parramore Springs	2,150	1928-1944	USED ^d	48.53	1937-38 1938-39 85.22 26.93
A06966	9N/2E-31	Plainfield	63	1886-1957	Private	16.29	1940-41 1938-39 36.71 7.15
A06971	9N/1E-24	Plainfield 2NNW	68	1938 to date	Private	15.73	1958-59 1940-41 11.25 33.52
F97109	17N/11W-6	Potter Valley Powerhouse	1,014	1911 to date	P.G.&E ^e USWB ^a	42.45	1957-58 1923-24 71.68 19.86
F97351	16N/12W-9	Redwood Valley	718	1937 to date	USWB ^a	34.13	1946-47 1957-58 23.69* 57.69
A87590	12N/3W-18	Rumsey	420	1937 to date	Private	23.02	1938-39 1940-41 8.94 44.68
A87591	12N/4W-12	Rumsey 1NW	455	1928 to date	Private	24.16	1938-39 1940-41 9.82 47.66
A98244	9N/7W-11	Silverado Ranch	2,380	1927-1939	Private	60.87	1930-31 1935-36 28.00 79.61
F98270	10N/10W-18	Skaggs Springs 2NE	340	1949 to date	SCFCWCD ^c	42.79	1949-50 1957-58 31.42 76.03
F98271	10N/11W-15	Skaggs Springs 2WNW	455	1945 to date	Private	48.43	1946-47 1957-58 30.14 95.61
A38579	18N/6W-28	Stonyford Durham	1,175	1929-40	Private	22.06	1938-39 1937-38 7.50 33.77
A38578	16N/7W-8	Stonyford Cooley Ranch	2,985	1935-44 1948 to date	Private USWB ^a	52.59	1957-58 1938-39 96.76 24.77
A38584	18N/7W-30	Stonyford Morris Ranch	2,500	1948 to date	Private	37.58	1957-58 1954-55 60.65 24.07
A38580	18N/6W-29	Stonyford Ranger Station	1,168	1918 to date	USFS ^h and USWB ^a	19.33	1946-41 1938-39 48.69 7.20
A38583	18N/7W-36	Stonyford 2SW	1,225	1948 to date	Private	22.02	1957-58 1956-57 45.38 13.68
F98885	11N/9W-23	The Geysers	1,600	1939 to date	USWB ^a	35.99	1957-58 1949-50 97.64 39.12
F99122	15N/12W-17	Ukiah	623	1877 to date	USWB ^a	35.06	1889-90 1923-24 60.48 16.19
A89167	15N/10W-2	Upper Lake 7W	1,520	1939 to date	USWB ^a	37.91	1940-41 1946-47 72.10 26.91
A89173	15N/9W-7	Upper Lake Ranger Station	1,347	1886 to date	USWB ^a	33.57	1957-58 1938-39 60.94 21.60
B99200	6N/1W-17	Vacaville	175	1880 to date	USWB ^a	24.22	1889-90 1938-39 50.05 9.90
F99725	8N/9W-11	Windsor	125	1949 to date	SCFCWCD ^c	35.99	1957-58 1956-57 77.93 27.77
A09742	8N/1W-15	Winters	135	1942 to date	USWB ^a	17.36	1957-58 1946-47 34.65 12.68

TABLE 1 (continued)

RECORDED MAXIMUM, MINIMUM AND ESTIMATED MEAN ANNUAL
PRECIPITATION AT STATIONS WITH MORE THAN TEN YEARS OF RECORD
IN OR ADJACENT TO THE CLEAR LAKE-CACHE CREEK BASIN

Location: number :	Township, range, and section :	Station	Elevation, in feet :	Period of record :	Source of record :	Estimated or recorded mean seasonal precipi- tation, in inches :	Recorded maximum and minimum season- al precipitation Season : In inches
A09743	8N/1W-29	Winters 1WSW	145	1932 to date	Private	20.65	1940-41 1938-39 46.52 8.19
A09745	8N/1W-33	Winters 1SSW (Wolfskill)	137	1937 to date	UC ^a	20.06	1940-41 1938-39 43.05 8.37
A99748	7N/2W-12	Winters 5SW	240	1938-53	Private	23.67	1940-41 1938-39 52.86 10.49
A09737	7N/1E-10	Winters Udell Ranch	140	1934-54	Private	17.98	1940-41 1938-39 36.86 7.07
A09746	8N/1E-13	Winters 3NE	116	1926 to date	Private	17.61	1940-41 1938-39 37.67 6.83
A09747	9N/2W-26	Winters Scott Ranch	320	1949 to date	Private	21.19	1957-58 1954-55 36.49 14.57
A09782	10N/2E-32	Woodland 1SSW	65	1933 to date	Private	16.81	1940-41 1938-39 34.61 7.96
A09784	9N/1E-20	Woodland 7WSW	103	1917 to date	Private	17.92	1940-41 1938-39 37.25 7.08
A09781	10N/2E-30	Woodland 1WNW	69	1873 to date	USWB ^a	16.16	1940-41 1897-98 33.52 6.41
A09785	10N/1E-26	Woodland Rumaey Ranch	93	1940 to date	Private	16.09	1956-57 1940-41 10.84 33.19
P89851	12N/13W-2	Yorkville	1,100	1939 to date	USWB ^a	45.76	1957-58 1946-47 79.33 34.60

- a - United States Weather Bureau
b - Southern Pacific Railroad
c - Sonoma County Flood Control and Water
Conservation District
d - United States Engineering Department
e - California State Division of Forestry
f - University of California
g - Pacific Gas and Electric Company
h - United States Forest Service
* - Also in 1954-55

Precipitation Characteristics

As previously stated, precipitation on the Clear Lake-Cache Creek Basin generally varies as a function of elevation, ranging from a mean seasonal depth of about 17 inches on the valley floor lands in the easterly portion of the basin to about 50 inches in the mountainous westerly portion. It was concluded from an analysis of records that precipitation at Lakeport, Davis, and Capay provides suitable indices of general precipitation over the basin. The record of precipitation at Lakeport is available since 1901-02, that for Capay since 1889-90, and that for Davis since 1871-72. Recorded annual precipitation for these stations is presented in Table 2.

TABLE 2
RECORDED ANNUAL PRECIPITATION
AT DAVIS, CAPAY AND LAKEPORT,
CLEAR LAKE-CACHE CREEK BASIN

(In inches)

Season	Davis	Capay	Lakeport	Season	Davis	Capay	Lakeport
1871-72	19.18			1935-36	17.79	21.21	31.29
1872-73	11.95			1936-37	18.89	21.79	24.62
1873-74	18.30			1937-38	25.79	36.53	44.28
1874-75	11.18			1938-39	6.99	8.90*	17.83
				1939-40	20.42	30.17*	34.71
1875-76	18.72						
1876-77	5.12			1940-41	31.51	47.37*	47.17
1877-78	20.00			1941-42	21.24	35.47*	38.32
1878-79	12.93			1942-43	17.83	22.02*	30.86
1879-80	17.03			1943-44	15.49	20.23*	21.48
				1944-45	15.43	19.39*	25.66
1880-81	18.85						
1881-82	11.63			1945-46	15.41	18.77	28.09
1882-83	15.78			1946-47	12.62	15.27*	21.11
1883-84	18.80			1947-48	14.08	16.33*	26.77
1884-85	9.79			1948-49	13.91	18.63	19.29
				1949-50	12.47	16.64	21.86
1885-86	24.50						
1886-87	12.23			1950-51	15.26	21.67	33.61
1887-88	12.00			1951-52	20.66	31.81	36.84
1888-89	20.13			1952-53	16.70	25.68	31.12
1889-90	37.41	45.30		1953-54	13.51	19.49	26.50
				1954-55	14.10	15.33	19.83
1890-91	21.38	18.89					
1891-92	12.42	16.31		1955-56	25.37	36.07	39.15
1892-93	24.31	36.49		1956-57	12.02	15.77	23.48
1893-94	15.16	16.42		1957-58	28.74	38.29	50.30
1894-95	22.58	35.18		1958-59	10.98	16.21	19.85
1895-96	21.71	29.24					
1896-97	18.82	19.93					
1897-98	8.96	9.92					
1898-99	13.19	15.57					
1899-00	13.29	17.45					
1900-01	17.79	23.58					
1901-02	15.72	25.67	34.44				
1902-03	16.19	19.70	26.20				
1903-04	18.47	24.11	43.15				
1904-05	22.75	31.07	36.27				
1905-06	24.46	26.77	37.33				
1906-07	23.93	30.96	34.33				
1907-08	13.16	15.11	21.65				
1908-09	22.07	29.10	44.47				
1909-10	11.77	19.80	23.22				
1910-11	23.18	31.84	25.99				
1911-12	9.46	12.23	19.22				
1912-13	8.74	12.59	23.47				
1913-14	28.70	35.98	44.56				
1914-15	20.05	30.12	40.37				
1915-16	20.88	27.62	26.25				
1916-17	14.11	18.27	21.75				
1917-18	9.66	14.13	17.49				
1918-19	19.40	21.00	27.02				
1919-20	8.94	9.92	14.19				
1920-21	17.17	23.16	35.99				
1921-22	16.63	20.14	21.76				
1922-23	17.86	22.64	26.61				
1923-24	8.99	10.62	14.09				
1924-25	19.25	25.58	38.70				
1925-26	18.35	27.23	24.24				
1926-27	18.95	25.76	36.86				
1927-28	14.76	20.28	26.70				
1928-29	10.94	14.99	16.64				
1929-30	13.90	21.63	23.46				
1930-31	8.73	10.30	12.69				
1931-32	15.21	21.57	21.80				
1932-33	9.56	12.66	16.70				
1933-34	11.04	17.03	22.24				
1934-35	18.71	22.68	29.93				

* Corrected records

As indicated by Table 2, precipitation in the Clear Lake-Cache Creek Basin fluctuates widely from year to year ranging from less than 50 percent to nearly 200 percent of the seasonal mean. As an example, maximum annual precipitation at Lakeport occurred in 1940-41, when 47.17 inches of rain were recorded. In 1923-24, the minimum year of record at this station, only 14.09 inches of rainfall were recorded. This variation in the annual occurrence of precipitation, and its apparent cyclic nature, is depicted graphically on Plate 3, entitled "Representative Precipitation and Runoff Characteristics in Clear Lake-Cache Creek Basin".

More than 80 percent of the annual precipitation in the Clear Lake-Cache Creek Basin occurs, on the average, during the 5 months from November through March. The mean monthly distribution of precipitation at Davis, Capay, and Lakeport, which are considered representative in this respect, is presented in Table 3.

TABLE 3

MEAN MONTHLY DISTRIBUTION OF RAINFALL
AT DAVIS, CAPAY, AND LAKEPORT

Month	Davis		Capay		Lakeport	
	:Percent:		:Percent:		:Percent:	
	: of :		: of :		: of :	
	In inches	annual	In inches	annual	In inches	annual
July	Trace	0	Trace	0	.02	.07
August	.01	.06	.02	.09	.04	.15
September	.18	1.10	.20	.91	.25	.91
October	.65	3.97	.79	3.60	1.33	4.85
November	1.50	9.16	2.02	9.22	3.06	11.16
December	3.29	20.10	4.44	20.26	5.59	20.39
January	3.67	22.42	4.97	22.67	6.13	22.38
February	3.00	18.33	4.28	19.52	4.73	17.26
March	2.28	13.93	3.22	14.70	3.37	12.29
April	1.14	6.96	1.25	5.70	1.76	6.42
May	.49	2.99	.55	2.51	.77	2.81
June	<u>.16</u>	<u>.98</u>	<u>.18</u>	<u>.82</u>	<u>.36</u>	<u>1.31</u>
Totals	16.37	100.00	21.92	100.00	27.41	100.00

Quantity of Precipitation

To evaluate ground water hydrology in the Clear Lake-Cache Creek Basin, estimates were made of the total quantity of precipitation on the ground water basins of Capay Valley and the lower Cache Creek area. The mean annual precipitation on those basins was determined by: (1) Plotting on a map recorded or estimated mean annual precipitation for all stations in or adjacent to the area and drawing lines of equal mean annual precipitation,

or isohyets, as shown on Plate 2, and (2) Multiplying the areas between isohyets, in acres, by the average depths of precipitation between these isohyets, in feet, to derive the total quantity of precipitation, in acre-feet.

Annual quantities of precipitation during the 6-year study period were estimated by adjusting the foregoing estimates for the mean period on the basis of recorded precipitation at Guinda, for the Capay Valley, and at Capay, Davis, Esparto, Winters, and Woodland for the Cache Creek Basin. The results of the estimates are presented in Table 4. The term "precipitation index" in Table 4 refers to the ratio of the amount of precipitation during a given year to the mean seasonal amount, expressed as a percentage.

TABLE 4

ESTIMATED WEIGHTED ANNUAL DEPTH
AND TOTAL QUANTITY OF PRECIPITATION
ON CACHE CREEK SERVICE AREA

Season	Capay Valley :			Cache Creek :			Total			
	: (58,200 acres) :			: (216,400 acres) :			: (274,600)			
	:Depth :Quantity :			:Depth :Quantity :			:Depth :Quantity :			
	Precipitation: in :	in :	Precipitation: in :	in :	Precipitation: in :	in :	in :	in :	in :	
	Index	inches:acre-feet:	Index	inches:acre-feet:	Index	inches:acre-feet:	Index	inches:acre-feet:	Index	inches:acre-feet:
1953-54	86	19.06	92,400	96	17.28	311,700	17.66	404,100		
1954-55	70	15.34	74,400	78	14.09	254,000	14.35	328,400		
1955-56	164	36.20	175,600	156	28.31	510,500	29.98	686,100		
1956-57	71	15.71	76,200	71	12.90	232,700	13.50	308,900		
1957-58	187	41.28	200,200	164	29.69	535,400	32.15	735,600		
1958-59	64	14.23	69,000	102	18.45	332,700	17.56	401,700		
Average for 6-year study period	107	23.64	114,600	111	20.12	362,800	20.87	477,500		
Mean for 50- year period	100	22.08	107,000	100	18.08	326,200	18.93	433,200		

Runoff

Runoff from rainfall constitutes the only significant source of water available for development in the Clear Lake-Cache Creek Basin. Stream flow, fed by runoff from the watershed areas, is used extensively for irrigation purposes in the lower Cache Creek area in the Sacramento Valley. However, a substantial portion is unregulated and wastes from the basin, particularly during wetter years, and constitutes a potential source of water to meet future requirements.

Stream Gaging Stations and Records

Records of stream flow for Cache Creek and its principal tributary streams are sufficient in number, length, and reliability for purposes of hydrologic studies. Records for most of the tributary streams, however, are of relatively short duration. To estimate runoff of these streams it was necessary to extend the records of runoff by correlation with nearby stations having records during the mean period.

Stream gaging stations pertinent to the hydrography of the Clear Lake-Cache Creek Basin, together with their reference numbers, drainage areas, and periods and sources of records are presented in Table 5. Locations of the stream gaging stations are shown on Plate 2. Reference numbers for all stations listed in Table 5 have been assigned by the Department of Water Resources. The numbers designate the major drainage and tributary basins in which the gaging station is located. Also, most of the runoff records for these stations have been published by the United States Geological Survey in its Water Supply Papers, or by the Department of Water Resources in its Bulletin No. 58.

It is significant to note that the Clear Lake staff gage located at Lakeport and known as the "Rumsey Gage" has long been recognized as the standard for measurement of water surface elevations of Clear Lake. Zero on the Rumsey Gage corresponds to an elevation of 1,318.59 feet above mean sea level. Location of the Rumsey Gage is shown on Plate 2.

TABLE 5
STREAM GAGING STATIONS IN OR ADJACENT TO
THE CLEAR LAKE-CACHE CREEK BASIN

Map* reference: number :	Location number :	Stream :	Location of gaging station :	Drainage area, in square miles :	Period of record :	Source of record** :
L-1	13N/9W-20N1	Adobe Creek	At Bell Hill Road	24	1948-50	DWR
CCI-1	12N/9W-5J	Adobe Creek	Near Kelseyville	6.4	October, 1954 to date	USGS
CCI-2	13N/9W-31D	Highland Creek	Near Kelseyville	12.7	October, 1954 to date	USGS
L-10	13N/9W-34K	Kelsey Creek	Near Kelseyville	37.2	December, 1945 to date	USGS
L-16	14N/10W-14M	Scott Creek	Near Lakeport	54	1948-1954 March, 1959 to date	USED DWR
CCI-3	15N/10W-12P	Scott Creek	At Upper Lake	106	November, 1959 to date	DWR
CCI-4	15N/9W-7E	Clover Creek	At Upper Lake	14	September, 1953 to date	DWR
CCI-5	15N/9W-6K	Clover Creek By- pass	Near Upper Lake		November, 1959 to date	DWR
L-19	15N/9W-5Q	Clover Creek	Near Upper Lake	14	1948-1954	USED
L-21	16N/10W-25N	Middle Creek	Near Upper Lake	47	1948-1954	USED
L-22	15N/10W-13A	Middle Creek	At bridge south of Upper Lake	83	1948-1950	DWR
CCI-6	15N/10W-1H	Middle Creek	Near Upper Lake	53	March, 1959 to date	DWR
CCI-7	12N/7W-14J	Copsey Creek	Near Lower Lake	14	January, 1960 to date	DWR
CCI-8	14N/10W-24R	Clear Lake	At Lakeport	528	1874-1900 incomplete January, 1913 to date	USGS
5-247	12N/6W-6B	Cache Creek	Near Lower Lake	528	May, 1944 to date	USGS
5-246	13N/7W-34R	Cache Creek	At Lower Lake	492	1901-1915	USGS
5-245	14N/6W-31F	North Fork of Cache Creek	Near Lower Lake	198	July, 1930 to date	USGS
CCI-9	13N/4W-30L	Bear Creek	Near Rumsey	99	September, 1955 to date	DWR
CCI-10	12N/4W-2J	Cache Creek	Above Rumsey	955	October, 1959 to date	DWR
CCI-11	12N/3W-18	Cache Creek	At Rumsey	962	1957 to date	DWR
5-248	10N/2W-8K	Cache Creek	Near Capay	1,052	May, 1942 to date	USGS
5-249	10N/1E-12K	Cache Creek	At Yolo	1,137	January, 1903 to date	USGS
PCI-1	9N/2W-25K	Salt Creek	Near Winters	10.8	1951-1954	DWR
PCI-1A	8N/1W-4A	Salt Creek	At Dunnigan Cutoff	16.2	March, 1952 April, 1952	DWR
PCI-8	9N/2E-28G	Willow Slough	Near Davis	173	1951-54	DWR
5-252	11N/6W-27E	Putah Creek	Near Guenoc	112	February, 1904 to July, 1906 July, 1930 to date	USGS

TABLE 5 (continued)

STREAM GAGING STATIONS IN OR ADJACENT TO
THE CLEAR LAKE-CACHE CREEK BASIN

Map* reference: number :	Location number :	Stream :	Location of gaging station :	Drainage area, in square miles :	Period of record to date :	Source of record** :
5-253	8N/2W-28A	Putah Creek	Near Winters	577	June, 1930 to date	USGS
5-254	8N/1W-22N	Putah Creek	At Winters	634	1905-1930	USGS

*L, Lake County Investigation
CCI, Cache Creek Investigation
5-245, Bulletin No. 1
PCI, Putah Creek Cone Investigation

**DWR, Department of Water Resources
USED, Corps of Engineers, U. S. Army
USGS, United States Geological Survey

Runoff Characteristics

Because runoff in the Clear Lake-Cache Creek Basin originates from rainfall, its monthly and annual pattern of occurrence is closely related to the monthly and annual variation in precipitation. Stream discharge increases greatly within a few hours following major storms. Runoff characteristics of the basin are exemplified by recorded and estimated annual runoff of Kelsey Creek in the Clear Lake Basin and Cache Creek in the Cache Creek Basin.

An excellent continuous record of flow of Cache Creek at Yolo is available since January, 1903, when a stream gaging station was established by the U. S. Geological Survey. This record of annual runoff is presented in Table 6, which also includes recorded and estimated annual runoff of Kelsey Creek near Kelseyville, North Fork Cache Creek near Lower Lake, Cache Creek near Capay, and Cache Creek at Yolo.

TABLE 6
RECORDED AND ESTIMATED ANNUAL
RUNOFF OF SELECTED STREAMS
CLEAR LAKE-CACHE CREEK BASIN

(In acre-feet)

Season	Kelsey Creek near Kelseyville	Recorded and estimated runoff at North Fork Cache Creek near Lower Lake	Recorded and estimated runoff of Cache Creek near Capay	Recorded runoff of Cache Creek at Yolo
1905-06	54,000	221,660	761,800	740,000
1906-07	68,500	266,650	997,900	983,000
1907-08	31,500	80,450	351,200	309,000
1908-09	89,000	313,250	1,294,400	1,280,000
1909-10	31,000	91,540	285,500	250,000
1910-11	43,000	193,210	528,300	496,000
1911-12	21,000	32,700	109,400	36,900
1912-13	28,000	56,900	187,100	73,200
1913-14	76,500	318,960	1,184,900	1,170,000
1914-15	68,500	254,740	1,036,200	999,000
1915-16	42,500	245,320	813,000	686,000
1916-17	29,000	104,180	341,500	145,000
1917-18	22,000	43,020	184,000	30,400
1918-19	33,500	115,980	256,000	107,000
1919-20	16,500	26,720	42,000	2,900
1920-21	57,000	173,160	505,200	389,000
1921-22	29,500	87,310	264,700	101,000
1922-23	30,000	103,260	230,000	92,900
1923-24	15,000	24,320	35,400	6,000
1924-25	48,000	123,720	351,800	240,000
1925-26	33,000	122,900	334,400	196,000
1926-27	70,000	186,730	846,000	682,000
1927-28	39,000	114,740	363,500	221,000
1928-29	20,000	33,840	87,000	18,700
1929-30	33,000	120,670	231,400	120,000
1930-31	17,500	15,100*	28,800	3,700
1931-32	30,000	74,400	145,800	75,800
1932-33	23,000	38,500	60,700	19,300
1933-34	25,000	48,300	115,000	45,400
1934-35	36,500	107,700	301,200	222,500
1935-36	43,000	140,600	484,500	335,700
1936-37	30,500	75,050	290,000	149,200
1937-38	85,000	360,000	1,283,600	1,172,000
1938-39	18,500	19,590	73,800	8,000
1939-40	57,000	213,300	666,300	558,400
1940-41	82,500	347,100	1,523,400	1,429,000
1941-42	61,000	234,100	1,013,500	894,300
1942-43	43,000	140,300	516,700*	341,500
1943-44	27,000	58,230	185,000	70,800
1944-45	33,000	83,260	242,300	86,000
1945-46	42,000*	135,200	394,600	197,300
1946-47	23,580	38,610	87,600	33,800
1947-48	28,160	68,020	160,200	36,700
1948-49	32,090	80,930	231,700	90,500
1949-50	29,110	67,000	178,400	65,400
1950-51	53,430	170,700	488,500	342,800
1951-52	71,480	255,200	889,500	729,200
1952-53	61,280	182,100	590,200	429,400
1953-54	50,750	122,800	424,300	253,500
1954-55	26,740	49,940	173,200	25,600
Mean for 50-year period	41,200	131,640	443,400	339,800

* Record begins

The apparent cyclic nature of the occurrence of runoff in the Clear Lake-Cache Creek Basin, as evidenced by the recorded and estimated annual runoff of Cache Creek near Capay, is depicted graphically on Plate 3. Comparison of the precipitation and runoff characteristics illustrated on Plate 3 demonstrates the relatively close correlation of annual variation between the two. The graphs of accumulated departure from mean annual runoff and precipitation, shown on Plate 3, serve as a useful and rapid guide in determining the relative wetness or dryness of any given period.

The average monthly distribution of runoff of representative streams in the Clear Lake-Cache Creek Basin is shown in Table 7. In this connection, it should be mentioned that the distribution of runoff of Cache Creek at Yolo reflects the summer irrigation season diversions at Capay and Moore Dams. Nearly 90 percent of the annual runoff in the basin occurs during the 5-month period from December through April. The monthly correlation between precipitation and runoff may be noted by comparison of Tables 3 and 7.

*Typical low summer
flow in Coche Creek*



*Department of Water
Resources photograph*



*Coche Creek at
flood stage, discharging
17,000 second-feet in
February, 1955*

*Department of Water
Resources photograph*

TABLE 7

AVERAGE MONTHLY DISTRIBUTION OF RUNOFF
AT SELECTED STATIONS IN PERCENT
OF RECORDED ANNUAL TOTALS

Month	: Runoff of :Kelsey Creek: : near :Kelseyville :	: Runoff of : North Fork of :Cache Creek near: : Lower Lake	:Runoff of : : Cache : : Creek : :near Capay:	: Runoff of :Cache Creek : at Yolo
October	1.2	0.3	0.5	0.1
November	4.1	1.6	0.8	0.6
December	19.9	14.8	8.2	6.2
January	23.0	21.6	18.5	19.7
February	20.1	27.8	21.9	30.0
March	15.2	18.6	15.0	22.7
April	9.0	10.4	9.9	14.4
May	4.3	3.4	6.0	4.1
June	1.6	1.1	5.7	1.3
July	.7	0.3	6.0	0.6
August	.4	0.1	5.0	0.2
September	<u>.5</u>	<u>0</u>	<u>2.5</u>	<u>0.1</u>
Totals	100.0	100.0	100.0	100.0

Quantity of Runoff

Quantitative determination of runoff in the Clear Lake-Cache Creek Basin was made for the purpose of evaluating potential dams and reservoirs, particularly at the Wilson Valley site, and for hydrologic analysis of those areas in the Cache Creek Basin overlying ground water storage, which are designated on Plate 1 as the "Cache Creek Service Area". The term "Cache Creek Service Area" will be used hereinafter in reference to the area of hydrologic analysis.

Available records of stream flow during the 6-year study period were sufficient to permit the determination of inflow to and outflow from the principal units of the Cache Creek Service Area. Moreover, the longer-term records at key locations enabled a reliable determination of runoff at potential dam sites, and provided a comparison of the relationship of runoff during the study period with that during the mean period.

Values of measured and estimated annual surface inflow to and outflow from the Cache Creek Service Area during the 6-year study period are presented in Table 8. Table 8 also shows annual runoff at key locations which are pertinent to plans for further water supply development. It will be noted in Table 8 that the inflow to the Cache Creek Service Area is comprised mainly of runoff from Cache Creek, which has been measured on the main channel near Lower Lake since 1945 and on the North Fork near Lower Lake since 1930. The remainder of inflow to the area derives from the small watershed areas flanking Capay Valley. Outflow from the Cache Creek Service Area is concentrated almost entirely in Cache Creek, which has been measured at Yolo continuously since 1903.

MEASURED AND ESTIMATED ANNUAL INFLOW TO
AND OUTFLOW FROM CACHIE CREEK SERVICE AREA

	Drainage : area, in : square : miles :	Season					Average : for : 6-year : study : period :
		1953-54 : 1954-55 :	1955-56 : 1956-57 :	1957-58 : 1958-59 :	1959-60 : 1960-61 :	1961-62 : 1962-63 :	
Inflow							
1 - Cache Creek near Lower Lake	528	228,500	105,200	549,200	114,900	741,600	223,500
2 - North Fork Cache Creek near Lower Lake	198	122,800	49,900	333,800	86,700	422,800	131,600
3 - Inflow to Wilson Valley Dam site	801	371,500	160,200	957,200	208,200	1,233,500	378,900
4 - Bear Creek near Rumsey	99	26,800	6,600	90,800	8,700	93,500	32,600
5 - Cache Creek accretions Wilson Valley to Rumsey	55	13,800	3,400	56,600	4,600	48,000	16,700
6 - Cache Creek accretions Rumsey to Capay	97	12,200	2,300	51,100	4,200	43,300	15,000
Total inflow (3+4+5+6) (Cache Creek near Capay)	1,052	424,300	173,200	1,155,700	225,600	1,418,400	443,200
Outflow							
Cache Creek at Yolo	1,137	253,500	25,600	1,051,300	82,500	1,348,000	339,800
Willow Slough: Winter runoff	173	6,300	5,000	48,000	3,000	55,000	11,000
Runoff of applied surface water		11,100	10,900	8,600	7,600	6,600	7,000

Underground Hydrology

The valley floor lands in the Clear Lake-Cache Creek Basin are underlain by water-bearing materials of considerable storage capacity, particularly in the Cache Creek Service Area. Water pumped from underground storage serves nearly all the lands irrigated within the Clear Lake Basin, and meets a substantial portion of the water requirements for irrigation and domestic uses within the Cache Creek Basin. The remainder of the water requirements of the latter basin are met from water developed and distributed by the Clear Lake Water Company. Percolation of precipitation and stream flow are the most important sources of ground water replenishment, while percolation of the unconsumed portion of applied irrigation water and of losses from canals and laterals constitutes a secondary, although significant, source of replenishment.

Clear Lake Basin

In the Clear Lake Basin, ground water bodies of significant extent underlies Big Valley, Scott Valley, and the Upper Lake area. The underground hydrology of these areas was studied in detail and reported upon in Department of Water Resources Bulletin No. 14, "Lake County Investigation". In that investigation it was determined that the 1955 net draft on ground water storage aggregated about 37,000 acre-feet per year, which draft could be increased to 50,000 acre-feet per year by utilizing additional ground water storage capacity. Because of the coverage of underground hydrology in Bulletin No. 14, further discussion or evaluation of ground water potential in the Clear Lake Basin will not be presented herein.

Cache Creek Basin

The discussion of underground hydrology in this section concerns the occurrence, quantity, and safe annual yield of ground water in the Cache Creek Service Area, together with the consideration of certain other items pertinent to the development and recharge of ground water.

The term "free ground water" as used in this bulletin refers to a body of ground water which can be replenished by direct percolation of overlying surface waters and which moves in direct relation to the slope of the water table. "Confined ground water" refers to a body of ground water overlain by material sufficiently impervious to sever hydraulic connection with overlying water, and which moves under pressure caused by the difference in elevation between the intake and discharge areas of the confined ground water body. In areas of free ground water the ground water basin provides regulatory storage to smooth out fluctuations in available water supplies, and changes in ground water storage are indicated by changes in ground water levels. Changes in water levels in confined ground water areas are indicative of changes in pressure of the confined water and generally do not directly indicate changes in storage capacity.

Ground water in the Cache Creek Service Area is, for the most part, free or unconfined, but many deep wells show "semiconfined" effects. As previously stated, these basins are replenished from percolation of rainfall, stream flow, and the unconsumed portion of applied irrigation waters.

Ground Water Geology, Cache Creek Basin

The geology of the Cache Creek Basin has been studied by various state and federal agencies and by several oil companies.

Published reports from these sources have been utilized in connection with the current investigation. Pertinent results of these studies are briefly summarized herein, and are presented in greater detail in an office report on file in the department.

Because the areal extent of water-bearing formations in the Cache Creek Basin closely conforms to the Cache Creek Service Area, evaluation of the ground water geology of the basin was essentially limited to that area. Areal distribution of the water-bearing and nonwater-bearing formations throughout the Cache Creek Basin is depicted on Plate 4, entitled "Geology of Cache Creek Basin". Reference to Plate 4 will facilitate understanding of the following discussion.

The Cache Creek Basin is underlain by folded and faulted consolidated sedimentary rocks of Cretaceous and Tertiary age which contain little useable ground water. These older rocks are overlain by the following water-bearing formations: Tehama formation and related continental sediments of Plio-Pleistocene age; older alluvium and terraces of Pleistocene age; and stream channel, terrace, flood plain, and other alluvial deposits of Recent age.

The occurrence and movement of ground water in the Cache Creek Basin are controlled to a large extent by the pattern of ridges and valleys in the area. This pattern was established by the warping and buckling of the earth's crust which began in the Pliocene and continued through the Pleistocene and which resulted in the present elevation of the northern Coast Range. The ridges appear to separate the Sacramento Valley from the

smaller valleys to the west. Structurally, Capay Valley is a broad, elongated synclinal depression between the Blue Ridge of the Vaca Mountains and the Rumsey Hills in the Coast Range geomorphic province. Although separated by the Rumsey Hills, Capay Valley as a ground water basin is imperfectly connected at its outlet with the Sacramento Valley ground water basin. Hungry Hollow is a low plains re-entrant which extends 7 to 8 miles north of Cache Creek between the Rumsey Hills anticline and the Dunnigan Hills anticline. Except for the partial separation by the Dunnigan Hills, the Hungry Hollow plain physiographically is a part of the Sacramento Valley. Similarly, the plain between the Plainfield Ridge and the Vaca Mountains physiographically is a part of Sacramento Valley. The Dunnigan Hills and the Plainfield Ridge act as partial barriers to ground water movement except where gaps in the ridges have been filled with pervious alluvial deposits.

The following list summarizes the geologic formations in the Cache Creek Basin, their ages, and their water-bearing characteristics:

<u>Formation</u>	<u>Age</u>	<u>Water-bearing characteristics</u>
Sediments of the Chico group	Cretaceous	Relatively impervious. Small amounts of water encountered are generally saline
Capay	Eocene	Relatively impervious and nonwater bearing except along fractures and joints
Tehama formation and related continental sediments	Plio-Pleistocene	Sediments are low to moderate in permeability but yield appreciable quantities of excellent quality water to wells

<u>Formation</u>	<u>Age</u>	<u>Water-bearing characteristics</u>
Older alluvium	Pleistocene	Basal section is very permeable and yields large quantities of excellent quality water. Upper section is fine-grained and low in permeability
Younger alluvium	Recent	Deposits are moderate in permeability and capable of absorbing and transmitting rainfall and excess irrigation water to the underlying formations
Stream channel deposits	Recent	Coarse sand, gravels, and cobbles of high permeability

Alluvium blankets almost all of the Cache Creek Service Area. Coarse alluvial or stream channel deposits are fairly well defined along Cache Creek from Esparto to the Dunnigan Hills. East of the Dunnigan Hills the coarse channel deposits fan out and do not lie in a single, well-defined train. The coarse well-sorted gravelly deposits are as much as 150 feet thick near Woodland, but farther west the base of the gravel apparently rises, and the gravelly deposits may be only about 40 feet thick in the constriction between the Dunnigan Hills and the Plainfield Ridge. The location of the Plainfield Ridge is shown on Plate 4. How much of these deposits is of Recent age is not known, but the materials at the land surface obviously are Recent.

In the Cache Creek Service Area, ground water is stored in two poorly defined zones. The upper zone is comprised of permeable stream channel deposits and younger and older alluvium; the semiconfined lower zone consists of a thick section of variably consolidated Tehama formation and related continental

sediments which underlie the area. Studies show that wide variation exists between water levels in adjacent deep and shallow wells during and immediately after the pumping season, but the levels recover to approximately equal elevations after winter recharge. This means that the zones are not well defined or separated from one another.

Useable ground water in the Cache Creek Service Area generally moves in a southeasterly direction toward the Sacramento River. Replenished by percolation of rainfall and surface runoff, the ground water moves down the slope of the gently dipping Tehama formation and related continental sediments into the valley. Anomalous water levels, and the presence of occasional falling water in wells, are evidence of the variable characteristics of the water-bearing deposits in these sediments. In the younger and older alluvium, ground water movement is retarded by the Plainfield Ridge. This ridge, actually formed by two ancient flexures in the Tehama formation, is partially buried by younger sediments. Easterly ground water movement is slowed down through the Plainfield Ridge and seems to be partially diverted to the south.

Specific Yield and Ground Water Storage Capacity

The term "specific yield" refers to the ratio of the volume of water that saturated soil will yield by gravity, to its own volume, and is expressed as a percentage. Ground water storage capacity is estimated as the product of the specific yield and the volume of material in the depth interval considered.

Generally, useable ground water storage capacity is limited to zones of unconfined ground water, wherein fluctuations in water levels represent an increase or decrease in the actual volume of water in storage. This is in contrast to zones of confined ground water, wherein fluctuations in water levels generally represent only changes in piezometric surface elevations, and do not indicate changes in ground water storage. Although, as stated, many wells in the Cache Creek Service Area exhibit semiconfined characteristics, ground water is generally unconfined on an areal basis, and fluctuations in water levels are considered to be representative of changes in ground water storage.

Determination of specific yield involves the evaluation of physical characteristics of the several types of water-bearing materials generally found in alluvial formations, of which the Cache Creek Service Area may be considered a typical example. Values of specific yield for each of the several principal classifications of materials were taken from estimates published in State Water Resources Board Bulletin No. 1, and are shown in the following tabulation.

<u>Material</u>	<u>Specific yield, in percent</u>
Gravel	25
Sand, including sand and gravel	20
Fine sand, tight sand, sandstone and related deposits	10
Clay and gravel, cemented gravel and related deposits	5
Clay, silt, sandy clay, and related fine-grained deposits	3

Utilizing the foregoing specific yield characteristics, the logs of several hundred wells were analyzed to determine the average specific yields of individual wells by depth intervals from 20 to 50 feet, 50 to 100 feet, 100 to 200 feet, and for the entire interval from 20 to 200 feet below ground surface. Total ground water storage capacity was determined for each specific depth interval as the product of the weighted average specific yield for the particular interval, in percent, the depth range of the interval, in feet, and the area studied, in acres.

Storage capacity of the ground water basin underlying the Cache Creek Service Area and the weighted average specific yield for the stated depth intervals are shown in Table 9. It will be noted in Table 9 that the estimates are shown separately for Capay Valley and the remainder of the Cache Creek Service Area, which is designated the "lower Cache Creek area". Because of the subsurface geologic configuration in Capay Valley, indicated ground water storage capacity was reduced by 20 percent.

TABLE 9

ESTIMATED WEIGHTED AVERAGE SPECIFIC YIELD
AND GROUND WATER STORAGE CAPACITY,
CACHE CREEK SERVICE AREA

Depth interval, in feet	Specific yield, percent		Ground water storage capacity, acre-feet	
	:Capay Valley	:Lower Cache: Creek area	:Capay Valley	:Lower Cache: Creek area
20 - 50	9.9	7.9	32,700	386,000
50 - 100	5.0	7.7	27,500	627,000
100 - 200	4.5	7.8	39,600	1,271,000
20 - 200	6.2	7.8	99,800	2,284,000

Yield of Wells

Wells capable of producing sufficient water for agricultural, industrial, and municipal purposes may be drilled throughout most of the Cache Creek Service Area. Highest yields are usually obtained from wells extracting water from the older alluvium, especially in proximity with the readily recharged gravels of Cache Creek. Aquifers in the Tehama formation are for the most part not as permeable as those in the older alluvium; consequently, deeper wells are usually required to produce comparative yields.

Data on the yield and specific capacity of wells in the Cache Creek Service Area are presented in Table 10, which summarizes data obtained from well pumping tests made by the Pacific Gas and Electric Company. The term "specific capacity" refers to the number of gallons per minute produced by a pumping well per foot of drawdown. The term "drawdown" refers to the depth of lowering of the water level in a well caused by pumping. In comparison with statewide averages, the average specific capacity of wells in the Cache Creek Service Area is excellent.

TABLE 10
YIELD AND SPECIFIC CAPACITY OF WELLS
IN CACHE CREEK SERVICE AREA

	: : Number : of wells : tested	: Maximum : discharge : (in gallons : per minute)	: Average : discharge : (in gallons : per minute)	: : Maximum : specific : capacity	: : Average : specific : capacity
Lower Cache Creek area	180	3,150	1,150	500	79
Capay Valley	14	1,410	660	350	91

Ground Water Measurements

Records of ground water level measurements in the Cache Creek Service Area date back to 1912 when the U. S. Geological Survey investigated the geology and ground water resources of the Sacramento Valley. Since that time ground water levels have been measured periodically by various interested agencies, principally since 1930. Of particular significance to this current investigation is the record of semiannual measurements of a grid of wells maintained since 1931 by the Yolo County Farm Advisor. A list of the agencies which have measured wells in the Cache Creek Service Area prior to the current investigation is shown in Table 11, together with the frequency of measurement and the period of record.

TABLE 11

GROUND WATER MEASUREMENTS AVAILABLE
IN CACHE CREEK SERVICE AREA

Agency	Period of record	Frequency of measurement
State Department of Water Resources	1929-1941 1952 to date 1951-1953, 1958 to date 1951-1954	Annually Semiannually Monthly Weekly
U. S. Geological Survey	1912-1913 1948-1950 1948-1951, 1958 to date 1948-1951	Annually Semiannually Monthly Weekly
University of California (Davis campus)	1931-1942	Semiannually
U. S. Bureau of Reclamation	1952 to date	Monthly and Semiannually
Yolo County Farm Advisor	1931 to date	Semiannually
City of Davis	1950 to date	Weekly
City of Woodland	1948 to date	Monthly
Private owners	Various	Annually

The Division of Water Resources made weekly measurements at a grid of 35 key wells during the period from 1951 through 1953 and, in addition, installed and operated continuous water stage recorders at selected wells to provide additional information on fluctuations of the water table. During the current investigation the department made monthly and semiannual measurements at 40 wells along several lines extending outward from Cache Creek. These measurements supplemented the semiannual measurements at 183 wells in 1958 and 187 wells in 1959, made by the Yolo County Farm Advisor. The purpose of these measurements was to

observe the behavior of the ground water basins under varying conditions of draft and recharge, and the percolation characteristics of Cache Creek. Records of well measurements made during the current investigation are on file with the department.

Depths to ground water throughout the Cache Creek Service Area, as measured during the fall of 1959, were plotted on a map and lines of equal depth were drawn. This is shown on Plate 5, entitled "Lines of Equal Depth to Ground Water, Fall of 1959". Plate 6, entitled "Lines of Equal Elevations of Ground Water, Spring of 1959", and Plate 7, entitled "Lines of Equal Elevation of Ground Water, Fall of 1959", were prepared by subtracting depths to ground water from elevations of the measuring points above sea level. While lines of equal depths, such as shown on Plate 5, serve as a useful guide in determining approximate static depths to the water table for any particular area, it must be remembered that any operating pump causes a cone of depression, or drop, in the surrounding water table, and that this additional lowering must be added to the static depths to determine total pumping lifts.

Lines of equal elevation, as shown on Plates 6 and 7, are more revealing than lines of equal depth, in that they indicate the generally west to east direction of ground water movement; recharge areas, such as those adjacent to Cache Creek; effects of pumping withdrawals, such as around the City of Davis; and the influence of such subsurface features as the Plainfield Ridge, which restricts movement of ground water, causing the contours to be steepened.

Ground Water Levels

Ground water levels in the Cache Creek Service Area undergo monthly and annual fluctuations in compensating for the seasonal and cyclic unbalance between replenishment and draft. This fluctuation is exemplified in Table 12, which shows recorded spring and fall depths to ground water over the past 20 to 30 years at selected wells considered to be representative of the Cache Creek Service Area. Fluctuations in depth to ground water at certain of the wells shown in Table 12 are illustrated graphically on Plate 8, entitled "Measured Depths to Water at Selected Wells". The locations of these wells are shown on Plate 7. Behavior of these typical wells is briefly discussed in the following paragraphs.

The hydrograph of well number 9N/2E-16E1, located 3.5 miles due south of Woodland in an area of historically heavy pumping, indicates that water levels remained relatively constant until 1947, except for periods of heavy recharge during the early 1940's. After 1946, however, increased agricultural pumping, combined with reduced recharge during the drought period of the latter 1940's, caused levels to drop until heavy recharge in the years 1952-1954 and 1956-1958 again caused a rise in elevation.

Well number 10N/1W-9E1 was selected as typifying water levels in the Hungry Hollow area. Its hydrograph reflects the cyclic variation of water supply more than the variation in annual pumping draft. Ground water levels in this area have risen and remained above those of the early 1930's. In four out of the last six spring measurements, the water table in this particular well has been at least 15 feet above that of 1934.

TABLE 12

DEPTHS TO GROUND WATER IN REPRESENTATIVE WELLS
CACHE CREEK SERVICE AREA

(In feet)

Well number	8N/1W-	8N/1E-	9N/1E-	9N/2E-	10N/1W-	10N/1W-	10N/2E-	11N/3W-
	22D1	15B1	28F1	16E1 ^b	9E1 ^b	29M1 ^b	21M2 ^b	15G1 ^b
Elevation of land surface, in feet:	126	83.48	101	53	167.0	165.4	52	330.8
Depth of well, in feet	78	116.7	47.5	170	-----	80	50	100.0
<u>Date</u>								
Spring 1913	27.0 ^a							
Fall 1931	43.0	25.2			24.4	13.7		
Spring 1932	----	22.6	14.4		----	----		
Fall 1932	40.1	24.1	18.4		21.8	12.4		
Spring 1933	----	23.2	18.7		22.3	----		
Fall 1933	44.3	26.1	20.0		26.3	15.2	20.6	
Spring 1934	----	26.0	20.8		25.8	13.4	13.7	
Fall 1934	45.2	27.0	20.7		26.2	14.2	21.7	
Spring 1935	----	25.1	20.1		22.4	13.1	15.7	
Fall 1935	----	25.8	17.5	17.7	21.8	13.0	18.2	
Spring 1936	----	23.8	16.0	14.8	17.8	10.8	12.5	
Fall 1936	34.2	23.7	13.0	15.5	17.8	9.7	16.0	
Spring 1937	----	21.6	11.0	12.3	13.1	6.2	10.6	
Fall 1937	37.1	22.6	10.0	14.3	11.5	8.5	16.0	
Spring 1938	----	-----	9.2	15.5	7.6	5.4	7.8	
Fall 1938	----	19.9	11.0	12.2	10.0	7.8	12.7	
Spring 1939	32.3	21.5	11.0	16.2	11.8	12.7	12.7	
Fall 1939	----	23.1	15.6	18.1	18.4	10.2	18.3	
Spring 1940	----	20.7	11.9	13.4	10.5	6.0	10.0	
Fall 1940	----	21.8	10.0	18.2	11.0	13.3	16.4	
Spring 1941	----	13.8	6.9	6.6	5.0	4.3	7.1	
Fall 1941	----	17.9	8.5	12.7	7.9	8.3	12.5	
Spring 1942	----	----	7.1	8.5	6.2	5.1	7.4	
Fall 1942	----	17.8	7.6	10.9	3.9	6.0	12.2	
Spring 1943	----	----	-----	7.7	6.7	9.2	8.8	
Fall 1943	----	----	-----	9.4	4.2	4.2	13.2	
Spring 1944	----	----	-----	10.0	9.8	7.4	10.5	
Fall 1944	----	----	-----	14.4	9.2	5.5	14.2	
Spring 1945	----	----	-----	13.1	10.8	6.2	10.7	
Fall 1945	----	----	-----	16.9	7.3	5.2	16.0	
Spring 1946	----	----	-----	16.4	8.5	6.3	11.3	
Fall 1946	----	----	-----	11.7	6.2	5.1	17.1	
Spring 1947	----	----	-----	16.6	12.4	8.7	14.8	
Fall 1947	43.4	----	-----	21.7	17.8	10.1	19.2	
Spring 1948	----	----	-----	19.2	17.2	10.4	18.2	
Fall 1948	----	24.2	-----	28.2	12.4	10.1	24.3	
Spring 1949	43.4	24.7	-----	27.1	10.5	8.2	18.3	
Fall 1949	45.9	26.9	-----	35.5	10.6	10.1	27.0	
Spring 1950	41.9	26.0	-----	40.7	11.5	9.9	22.1	
Fall 1950	48.8	27.6	-----	37.1	17.1	12.8	30.7	
Spring 1951	----	25.4	-----	33.5	10.8	7.0	23.2	
Fall 1951	41.9	27.9	10.6	39.4	10.0	7.8	28.9	
Spring 1952	----	25.5	-----	41.8	7.7	5.5	16.0	
Fall 1952	41.5	26.4	9.6	34.7	7.2	4.4	25.3	
Spring 1953	37.6	24.6	8.7	22.7	5.2	5.5	16.0	18.1
Fall 1953	48.2	27.0	9.6	31.5	10.6	5.8	25.5	25.5
Spring 1954	39.2	26.7	9.7	22.8	12.3	7.0	18.3	19.1
Fall 1954	52.9	27.6	11.4	35.0	10.1	10.0	26.5	23.6
Spring 1955	45.9	28.6	11.4	33.8	10.5	10.8	23.1	25.8
Fall 1955	58.5	31.7	13.3	40.6	17.7	15.0	30.2	25.8
Spring 1956	46.8	25.5	10.5	----	9.7	5.5	18.5	21.8
Fall 1956	----	27.6	-----	35.0	18.0	9.0	25.0	23.5
Spring 1957	48.4	29.3	-----	----	20.5	8.0	27.0	21.5
Fall 1957	----	32.4	-----	40.4	19.2	----	30.3	23.6
Spring 1958	----	24.7	-----	20.8	8.1	6.5	23.0	12.7
Fall 1958	----	27.2	-----	32.1	15.8	12.1	20.9	22.4
Spring 1959	----	28.1	-----	20.7	12.3	8.0	17.7	19.2
Fall 1959	----	29.6	-----	----	21.3	14.1	26.2	23.3
Spring 1960	----	32.2	-----	30.8	20.1	11.0	27.0	----
Fall 1960	----							

a - This measurement from United States Geological Survey
Water Supply Paper 495.

b - Measurements from Yolo County Farm Advisor.

The hydrograph of well number 10N/1W-29M1, located about 2 miles west of Madison, shows the least long-time fluctuation anywhere in the Cache Creek Service Area. Heavy surface application of water in combination with limited percolation from Cache Creek, plus the fact that eastward flow is restricted by the Plainfield Ridge, all tend to keep the water table high and relatively stable.

Well number 11N/3W-15G1, located about 1.5 miles south of Guinda, was selected to show average fluctuation of ground water levels in Capay Valley. While there are no long-term records in this area, measurements having been initiated in 1953, fall to spring recovery appears to reflect the relative wetness of the winter, and there is no indication that drawdown during the irrigation season exceeds the average annual replenishment.

As indicated in Table 12 and on Plate 8, spring measurements, normally being made at the end of the recharge season and before the pumping season begins, represent maximum elevations of the water table in any given year. Conversely, fall measurements, usually made at or near the end of the pumping season and prior to the recharge season, represent the minimum elevation of the water table for that year.

A comparison of the earliest available ground water elevation map for the Cache Creek Service Area, showing levels in 1912, with a map depicting present (1959) levels, indicates that the past and present configuration of contours is practically identical, although present water levels generally are lower. In 1912-13, ground water elevations, referenced to mean sea level, U. S. Geological Survey datum, were about 50 feet near Woodland,

30 feet near Davis, 100 feet near Winters, and 140 feet near Madison. Even at that early date, it was evident that formations comprising the Plainfield Ridge were obstructing ground water movement to the east. Recent ground water elevation maps depicting fall levels (Plate 7) indicate the presence of several ground water depressions, especially around or near such cities as Davis and Woodland. Increases in pumping east of the Plainfield Ridge have steepened the gradient across this obstruction so that the effect of this ridge is apparent from Cache Creek to Putah Creek.

It is interesting to note that, except for those localities bordering the ground water area, the greatest depth to ground water occurs about 5 miles west of Woodland. This trough or depression is caused by increased pumping plus the fact that ground water movement is restrained in and through the Plainfield Ridge. The large area northeast of Winters and west of the Plainfield Ridge has historically had shallow depths to water. The larger part of this area south of State Highway 16 has been under surface water irrigation for a considerable length of time.

From a study of all available well measurements, estimates were made of the approximate average depth to ground water in the Cache Creek Service Area in the fall of each year since 1931, except for Capay Valley, for which measurements commenced in 1953. These average fall depths are shown in Table 13, and are depicted graphically on Plate 8. The fluctuations indicated by the tabulation and graph result from a combination of three factors, namely: the wetness of the year with resultant winter recharge; the

magnitude of surface diversions, with resultant summer season recharge; and the magnitude of ground water draft. It can be concluded that the wetness of the year is the most significant item influencing ground water levels, because of the increased replenishment both by percolation from Cache Creek and from precipitation, and by percolation from the abundant surface diversions. The effect of wet years can be noted by the sharp recovery of ground water levels during 1939-41, 1950-52, 1955-56, and 1957-58. The effect of the heavy increase in ground water extraction following World War II is accentuated by the years of deficient water supply during the latter 1940's.

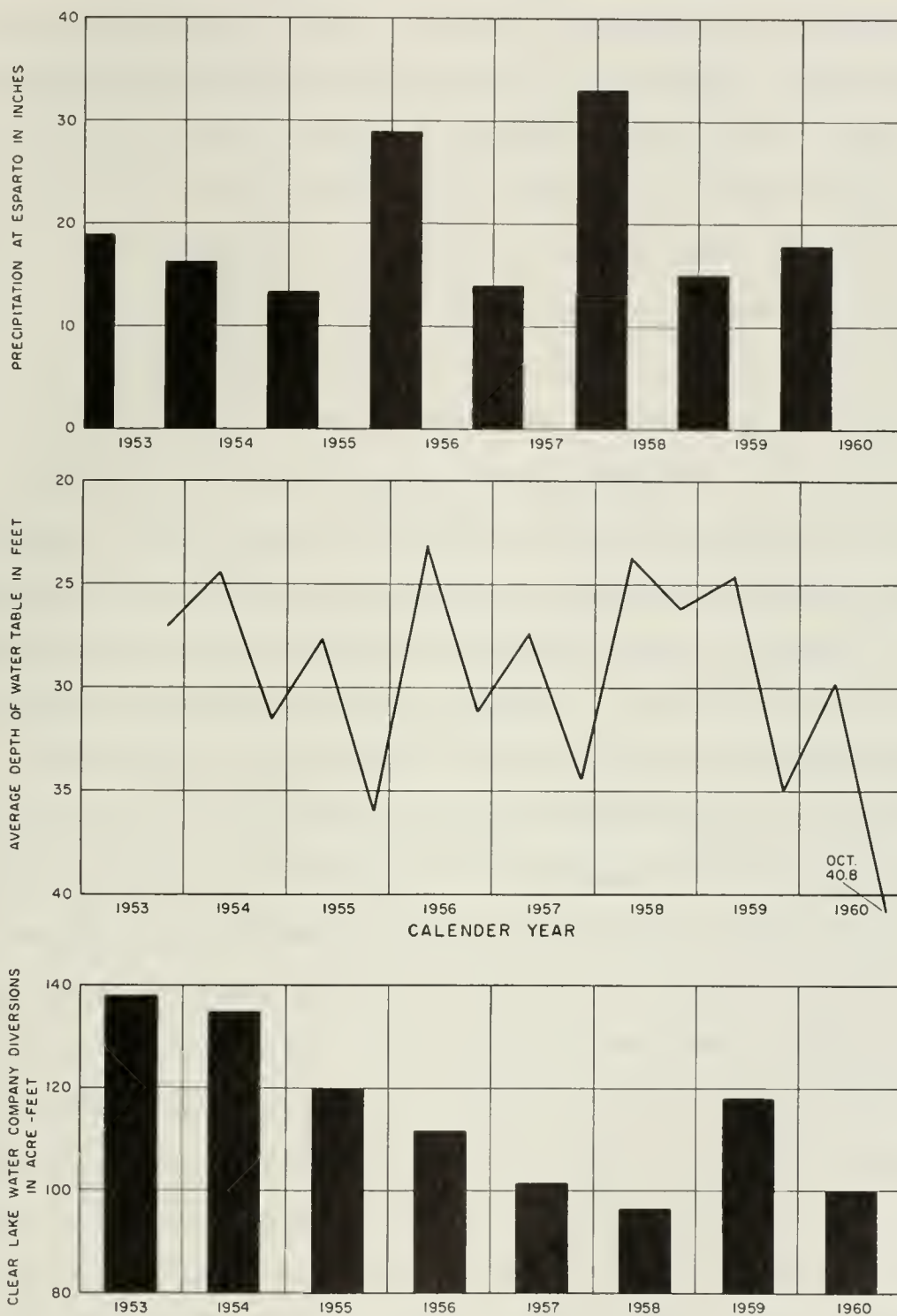
TABLE 13
AVERAGE FALL DEPTH TO GROUND WATER
(In feet)

Year	Yolo Service Area	Capay Valley	Year	Yolo Service Area	Capay Valley
1931	24.8*		1946	18.9*	
1932	26.5*		1947	25.1*	
1933	27.6*		1948	28.0*	
1934	28.6		1949	29.6*	
1935	23.6*		1950	35.3*	
1936	22.8*		1951	28.5*	
1937	21.0*		1952	23.9*	
1938	17.4*		1953	26.9	23.8
1939	24.0*		1954	31.6	23.8
1940	20.7*		1955	35.9	26.4
1941	16.9*		1956	31.0	24.0
1942	16.8*		1957	34.5	28.6
1943	15.4*		1958	26.2	27.0
1944	19.0*		1959	34.9	24.7
1945	19.0*				

* From Putah Creek Cone Investigation.

The relationship between winter season recharge and summer season pumping draft can be better appreciated by reference to the graph depicted as Figure 1. This graph, which illustrates

FIGURE 1



RELATIONSHIP OF SURFACE AND GROUND WATER SUPPLIES
IN CACHE CREEK SERVICE AREA

the spring and fall depths to water during the 6-year study period, reveals some interesting characteristics of ground water storage basins, in general, and of the Cache Creek Service Area, in particular. Primarily, it shows that variations in ground water levels from year to year are a function not only of pumping draft, but of winter recharge as well. The lowering of ground water levels in the fall due to increased pumping is not in itself indicative of overdraft; the significant consideration is the degree of recovery of ground water levels from recharge during the ensuing winter months. Moreover, since recharge varies directly with the available water supply from year to year, fluctuation in ground water storage is to be expected in accordance with the wetness or dryness of any given year or period of years.

Figure 1 also illustrates the close relationship between precipitation and surface diversions by the Clear Lake Water Company during the first 3 years of the 8-year period shown. This correlation would be expected, as the availability of water for diversion is a direct function of precipitation. However, this relationship does not hold for the last several years of the 8-year period, due primarily to the change in cropping patterns and the substantial reduction in acreage of rice, the crop of greatest water application. It will be noted in Figure 1 that the period of surface diversions nearly spans the rainless summer and fall season. The substantial ground water recharge from percolation of canal and application losses from surface supplies, particularly during wetter years, definitely reduces the fall ground water depths that otherwise would occur.

Change in Ground Water Storage

To secure a balance between the items of water supply and water disposal in the Cache Creek Service Area during the 6-year study period, it was necessary to determine the average annual change in ground water storage throughout the area during that period. Available data on ground water levels during the study period, utilized in conjunction with estimates of specific yield, enabled a fairly reliable derivation of change in ground water storage. Further, records and estimates of the principal items of water supply, water use, and change in ground water storage permitted a check on the reasonableness of criteria and assumptions regarding subsurface outflow and withdrawals from ground water storage during the study period, and enabled the determination of safe ground water yield which will be discussed in an ensuing section of this chapter.

Changes in ground water storage in the Cache Creek Service Area were estimated by multiplying changes in elevation of ground water by the product of the areas and depth intervals over which such changes occurred. The estimated annual changes from fall to fall for the 6-year study period are shown in Table 14. The cumulative change in ground water levels during the study period is depicted on Plate 9, entitled "Lines of Equal Change in Ground Water Elevations from Fall of 1953 to Fall of 1959".

TABLE 14

ESTIMATED ANNUAL CHANGES IN GROUND
WATER STORAGE IN CACHE CREEK SERVICE AREA
DURING SIX-YEAR STUDY PERIOD

Year	: Average change in		: Total change in	
	: elevation of ground		: ground water storage,	
	: water levels, in feet		: in acre-feet	
	: Lower Cache:		: Lower Cache	
	:Capay Valley:	Creek area	:Capay Valley:	Creek area
1953-54	0.8	-4.7	900	-60,500
1954-55	-1.1	-4.3	-1,200	-55,300
1955-56	2.1	+4.8	2,300	61,700
1956-57	-4.1	-3.5	-4,500	-45,000
1957-58	1.1	+8.3	1,200	106,800
1958-59	-1.6	-8.7	-1,700	-111,900
1953-1959	-1.8	-6.1	-1,800	- 79,500
Average for 6- year period	-0.3	-1.0	- 300	- 13,300

Subsurface Inflow and Outflow

Ground water movement is a function of the slope of the water table, the area through which the water moves, and the permeability of the water-bearing materials. Ground water contours indicate on the basis of slope, that subsurface inflow to the Cache Creek Service Area occurs in the underlying Tehama formation. However, the tributary watershed from which such subsurface inflow could occur is quite small; therefore, opportunity for subsurface inflow is quite limited. Moreover, any subsurface inflow which would occur is a direct function of precipitation on the tributary watershed. For this reason, the accretion to the water supply of the Cache Creek Service Area from this small watershed

was evaluated as the differential between total precipitation on the watershed and consumptive use of precipitation by the watershed vegetation.

Subsurface outflow in the Cache Creek Service Area derives from three sources; namely: (1) movement of ground water to the southeast toward the Yolo Bypass, (2) ground water movement into the Putah Creek Channel along the southerly edge of the service area, and (3) percolation from Cache Creek out of the service area to the north. The latter category of subsurface outflow requires further explanation. As shown on Plate 6, Cache Creek defines the northerly limits of the Cache Creek Service Area from the Dunnigan Hills eastward. The greater portion of percolation from Cache Creek in this reach moves southward and constitutes a supply to the Cache Creek Service Area. However, the percolation which moves to the north is not available for use in that area.

It has been determined that subsurface outflow from the Cache Creek Service Area is relatively constant from year to year. The average annual outflow from these sources is shown in the following tabulation:

	<u>Average for 6- year study period, in acre-feet</u>	<u>Mean, in acre-feet</u>
Cache Creek percolation to the north	9,600	6,700
Rising water in Putah Creek to the south	4,000	4,000
Subsurface outflow to the southeast	<u>7,300</u>	<u>7,300</u>
Totals	20,900	18,000

Water Quality

Mineral quality of the water resources of the Clear Lake-Cache Creek Basin has been considered with respect to suitability for agricultural and urban uses. In general, surface water in the basin may be described as a moderately hard calcium bicarbonate water. While the water normally would be classified as excellent for all uses, the presence of boron limits its use for agriculture in many areas. Concentrations of boron are greatest during low summer flows, but are substantially diluted by high spring and winter flows. Numerous mineral hot springs tributary to Cache Creek constitute the main source of this degradation.

Criteria for Quality of Water

Suitability of water for irrigation use is classified in accordance with four principal mineral constituents. These are: (1) total dissolved mineral solids, (2) chloride concentration, (3) sodium in percent of base constituents, and (4) boron concentration. Utilizing these criteria, irrigation waters have been divided into three broad classes, based upon work done by the regional salinity laboratories of the U. S. Department of Agriculture in cooperation with the University of California.

- | | |
|---------|--|
| Class 1 | Excellent to good, or suitable for most crops under most conditions |
| Class 2 | Good to injurious, or harmful to some plants under certain conditions |
| Class 3 | Injurious to unsatisfactory, or harmful to most plants under most conditions |

Tentative criteria for evaluation of irrigation waters under the three broad classes, taking into account the four mineral constituents, are listed in the following tabulation:

<u>Chemical properties</u>	<u>Class 1 Excellent to good</u>	<u>Class 2 Good to injurious</u>	<u>Class 3 Injurious to unsatisfactory</u>
Total dissolved solids in ppm	Less than 700	700 - 2,000	More than 2,000
Conductance, in micromhos at 25° C	Less than 1,000	1,000 - 3,000	More than 3,000
Chlorides in ppm	Less than 175	175 - 350	More than 350
Sodium in percent of base constituents	Less than 60	60 - 75	More than 75
Boron in ppm	Less than 0.5	0.5 - 2.0	More than 2.0

These criteria have limitations in actual practice. In many instances a water may be wholly unsuitable for irrigation under certain conditions of use, and yet be completely satisfactory under other circumstances. Consideration also should be given to soil permeability, drainage, temperature, humidity, rainfall, and other conditions that can alter the response of a crop to a particular quality of water.

Although hardness of water generally is not a factor in considering the suitability of water for irrigation uses, it is of considerable importance in domestic and industrial uses. Hardness, depending upon its degree, causes curdling and increased

consumption of soap, deposition of scale on boilers, injurious effects in certain industrial processes, and sometimes objectionable taste. The following tabulation for degrees of hardness has been suggested by the U. S. Geological Survey.

<u>Range of hardness, expressed as CaCO₃ in parts per million</u>	<u>Relative classification</u>
0 - 55	Soft
56 - 100	Slightly hard
100 - 200	Moderately hard
More than 200	Very hard

The following tabulation gives the limiting concentrations of mineral constituents for drinking water, as proposed by the U. S. Public Health Service, and adopted by the State of California.

U. S. Public Health Service
Drinking Water Standards
1946

<u>Constituent</u>	<u>Mandatory limit, in ppm</u>
Lead	0.1
Fluoride	1.5
Arsenic	0.05
Selenium	0.05
Hexavalent chromium	0.05
	<u>Nonmandatory, but recommended limit</u>
Copper	3.0
Iron and manganese together	0.3
Magnesium	125
Zinc	15
Chloride	250
Sulfate	250
Phenolic compounds	0.001
Total solids - desirable	500
- permitted	1,000

Water Quality Characteristics

Characteristics of quality of waters are discussed in this section for streams tributary to Clear Lake, North Fork Cache Creek, Bear Creek, Cache Creek, and the ground water basin underlying the Cache Creek Service Area.

Analyses of water from streams tributary to Big Valley, Scott Valley, and the Upper Lake area show that these waters are a calcium or calcium-magnesium bicarbonate type, with slight to moderate hardness. These waters do not contain significant amounts of boron and are of excellent quality, suitable for most beneficial purposes. A single analysis of a sample taken on Seigler Creek, west of Lower Lake, shows a moderately hard, sodium bicarbonate water. This supply would be of excellent quality, except for the presence of boron which indicates a Class 2 irrigation water.

Clear Lake water is a calcium or calcium-magnesium bicarbonate type of moderate hardness with a percent sodium generally less than 20. Boron ranges from 0.43 to 2.3 parts per million (ppm) and averages 1.1 ppm, while hardness ranges from 95 to 237 ppm with an average of 142 ppm. Here again, the presence of boron places the water in Class 2 for irrigation. Analyses of boron content from water taken at various points around Clear Lake indicate an unknown source of boron somewhere between Sulphur Bank Point and Lower Lake. Concentrations of boron in the lake have been observed to decrease with large inflows and to increase with small inflows. Also, a high lake level is characterized by a lower concentration of boron than is a low lake level. Such changes in boron content may be considered to be the result of dilution by inflow and concentration by evaporation.

Runoff from the upper watersheds of the North Fork of Cache Creek above the junction with Soap Creek is a soft to moderately hard calcium bicarbonate type water of excellent quality. The mineral content of North Fork Cache Creek is increased considerably by flows from tributary streams such as Soap, Bartlett, Stanton, Catenberg, and Wolf Creeks. These streams add extremely high concentrations of sodium, chlorides, boron, and total dissolved solids during periods of low flow. Runoff following the first fall rains is also high in mineral content.

The quality of water in North Fork Cache Creek above its junction with Cache Creek has been determined from monthly samples taken during the period from April, 1938 to September, 1941, at the U. S. Geological Survey stream gaging station 2.5 miles above the Highway No. 20 bridge. Analyses of these samples show the water to be of a very hard sodium bicarbonate type during low flow, but of a calcium bicarbonate type during periods of high flow. The high concentrations of boron in water of the North Fork during low flow conditions places this water in Class 3 for irrigation; however, the water would meet Class 2 criteria during the high winter and spring flows. A summary of the ranges of significant mineral constituents from these analyses is shown in the following tabulation:

	<u>Range</u>	<u>Average</u>
Sodium	7 to 72 ppm	37 ppm
Chloride	4 to 167 ppm	56 ppm
Boron	0.3 to 7.2 ppm	3.3 ppm
Total dissolved solids	48 to 558 ppm	295 ppm
Percent sodium	17 to 33 percent	25 percent
Total hardness	68 to 399 ppm	225 ppm

Water in the uppermost reaches of Bear Creek appear to be excellent for irrigation purposes. However, quality of water in lower Bear Creek becomes poor due to the presence of many mineral springs along the western slope of Bear Valley. One of the main sources of the highly mineralized water is Sulphur Creek, along which is located the old resort of Wilbur Springs. The waters of Bear Creek below Sulphur Creek Junction show the same type of highly mineralized, very hard, sodium bicarbonate water, containing excessive chlorides, boron, and percent sodium that is present in Sulphur Creek. The following tabulation shows ranges of mineral constituents in waters of Bear Creek below Wilbur Springs bridge, based upon analyses of 17 samples taken from June, 1938 to November, 1939.

<u>Mineral constituents</u>	<u>Range</u>	<u>Average</u>
Sodium	313 to 940 ppm	692 ppm
Chloride	403 to 1,500 ppm	894 ppm
Boron	9.4 to 34 ppm	21 ppm
Total dissolved solids	1,231 to 3,458 ppm	2,202 ppm
Percent sodium	58 to 81 ppm	73 ppm
Total hardness	473 to 571 ppm	511 ppm

Analyses of water samples taken from Bear Creek downstream from Wilbur Springs at Highway No. 20 bridge and at the junction of Cache Creek show a somewhat better quality water than in the foregoing tabulation, but still of sufficient boron content to place it in Class 3 for irrigation. Undoubtedly Bear Creek is one of the major sources of detriment to the quality of water in Cache Creek.

Mineral quality of water of the main stem of Cache Creek has been studied from daily and monthly samples taken at the U. S. Geological Survey station near Lower Lake, which reflects the quality of water released from Clear Lake, and from samples taken from Cache Creek at or near Capay Dam, the main point of diversion of irrigation water from Cache Creek. A comparison of the quality of water at these two sampling points shows the effects of the heavily mineralized waters that enter from North Fork Cache Creek and Bear Creek. As previously stated, waters of Clear Lake would be classified as excellent, except for the high concentrations of boron.

The following tabulation depicts ranges and averages for the more important mineral constituents of the Clear Lake releases. Higher concentrations of boron place these waters in Class 2 for irrigation.

<u>Mineral constituents</u>	<u>Range</u>	<u>Average</u>
Boron	0.74 to 1.4 ppm	1.0 ppm
Total dissolved solids	117 to 196 ppm	160 ppm
Percent sodium	14 to 24 ppm	18 ppm
Total hardness	88 to 164 ppm	133 ppm

Results of analyses at the downstream diversion point at Capay Dam indicate Cache Creek waters to be principally a good quality calcium-sodium bicarbonate-type with hardness ranging from moderate to very hard. As with Clear Lake, water in Cache Creek at Capay would be of excellent quality, except for the high concentrations of boron. The following tabulation lists the

ranges and averages of the more important mineral constituents in waters of Cache Creek at or near Capay Dam.

<u>Mineral constituents</u>	<u>Range</u>	<u>Average</u>
Sodium	15 to 130 ppm	43 ppm
Chloride	12 to 214 ppm	57 ppm
Boron	0.35 to 6.4 ppm	1.8 ppm
Total dissolved solids	171 to 661 ppm	326 ppm
Percent sodium	18 to 47 ppm	29 ppm
Total hardness	111 to 335 ppm	201 ppm

Water samples taken at or near Capay Dam from 1930 to 1956 show the quality of water in Cache Creek approaches the lower (better) limits of the ranges in the foregoing tabulation during extreme high flows, and to be generally of a calcium bicarbonate-type. It is also found that during periods of low flow the boron concentration is considerably higher than during periods of high flow. Since the major irrigation diversions are made from June to September, average concentration of boron in water applied to crops in this area probably would be somewhat higher than the 1.8 ppm average indicated above. In general, water diverted from Cache Creek would be classified as Class 2 irrigation water, primarily as a result of its boron content.

Referring to permissible limits of boron in irrigation water, as determined by the U. S. Department of Agriculture, water diverted from Cache Creek may be harmful to boron-sensitive crops. However, the boron concentrations probably would not limit the planting of crops which are semitolerant or tolerant to boron.

Of the crops grown in the area, English walnut and black walnut are classed as sensitive to boron. Tomatoes, oats, corn, barley, and olives are classed as semitolerant, while alfalfa and sugar beets are classed as tolerant. Tolerance of plants to boron cannot be measured absolutely, since such tolerance is, in part, dependent upon the type of soil upon which the plants are grown, amount of irrigation water application, and other factors encountered in actual farming practices.

Water from the ground water basin underlying the Cache Creek Service Area is of variable quality, but is generally hard or very hard. Ground water in the northern part of Hungry Hollow and in a strip about three miles wide along the north side of Putah Creek from Winters to Davis is typed as Class 1 irrigation water. The quality of the water from the remainder of the ground water basin is typed as either good or poor, primarily because of the boron concentration. The concentration of boron in the ground water basin undoubtedly is due to the long continued use of water diverted from Cache Creek for irrigation purposes. Furthermore, the hardness of the ground water makes softening desirable for use for municipal and domestic purposes.

It is noted from comparison of analyses of mineral quality of water sampled from wells in the Cache Creek ground water basin that water from the deeper wells has a lower boron concentration and a reduced hardness. However, in most cases the boron concentration is high enough to place the water in Class 2 for irrigation, and this water is also quite hard.

Two areas of Class 3 irrigation water occur in the Cache Creek Service Area ground water basin. The smaller area of this

type occurs just west of the Plainfield Ridge, about five miles east of Madison, and a more extensive area extends from northeast of the City of Woodland southerly along the eastern boundary of the ground water basin. This water is very hard and has a high boron concentration.

Safe Yield of Presently Developed
Water Supply

More than two-thirds of the present yield of the water supply of the Clear Lake-Cache Creek Basin is developed by pumping from underlying ground water sources. The remainder is developed by the operation of Clear Lake and Cache Creek to deliver irrigation water to the Cache Creek Service Area. Water requirements in the Clear Lake Basin are met almost entirely from ground water supplies. However, the Cache Creek Service Area, while relying primarily on pumping from underlying ground water sources, is served with substantial quantities of surface water through the extensive distribution system of the Clear Lake Water Company.

Many lands in the Cache Creek Service Area receive water both from surface sources and from ground water pumpage, the relative magnitude from each source being dependent upon the wetness of the particular year. During wetter years when surface supplies are plentiful, the bulk of the requirements in the service area are met by surface deliveries; however, during drier years, the irrigators must rely to a greater extent on pumpage from ground water. While the average annual surface diversions amount to about 100,000 acre-feet, actual diversions have varied from only 13,000 acre-feet to as much as 189,000 acre-feet per year. Thus, the

average annual surface diversion cannot be taken as the safe or firm yield of developed surface supplies. On the other hand, safe yield of the ground water resources is not a fixed quantity, because it is influenced to a considerable degree by the amount of surface diversions and the resultant percolation therefrom.

The yield of surface water supplies in the Clear Lake-Cache Creek Basin will be discussed and evaluated in Chapter IV, entitled "Plans for Water Development". This section will discuss and determine the safe yield of the ground water resources of the basin, as presently developed.

Safe Ground Water Yield

The term "safe ground water yield" refers to the maximum net rate of extraction from a ground water basin which may be sustained over a long period of time without causing certain unfavorable conditions. Criteria normally governing safe ground water yield are:

1. Extraction of water is limited to the mean annual ground water recharge.
2. Extraction of water must not so lower ground water levels as to cause degradation of mineral quality.
3. Extraction of water must not so lower ground water levels as to cause excessive pumping lifts or to exclude users from a supply.

Safe ground water yield, as derived in this bulletin, was measured by net extraction of water from free ground water zones, and by gross extraction of water in the confined zones. The reason for this difference in measurement in the two different

types of zones is that the unconsumed portion of gross pumpage cannot return to the ground water basin for re-use in confined zones. It was determined that confined ground water zones occur only in the Clear Lake Basin.

In most cases, the safe yield of the ground water basin is not determined until there is evidence of overdraft or use of water in excess of safe yield. Until pumping draft increases to a point beyond which overdraft conditions occur, the safe yield of the ground water basin would be equal to the draft thereon. This condition is currently the case in the Clear Lake Basin. An increase in pumping draft on the basin would correspondingly increase the safe ground water yield by further lowering ground water levels during drought periods, thereby providing additional space in the basin for storage of percolating surface waters that would otherwise waste from the basin during wet periods. As stated earlier in this chapter, the present safe ground water yield of the Clear Lake Basin, as determined by the 1954 draft thereon, amounts to 37,000 acre-feet per year.

The lower Cache Creek area of the Cache Creek Basin is known to be experiencing an overdraft condition in that the pumping draft on the ground water resources of that area has increased to a point where it exceeds safe ground water yield. In the absence of any indication of degradation of quality of the ground water or of the exclusion of users of the supply, it has been determined that the first of the foregoing three criteria, in which extraction of water is limited to the mean annual ground water recharge, applies for that area.

Derivation of the safe ground water yield for the Cache Creek Service Area for the 6-year study period and for the mean period, under present development, is presented in Table 15. It should be noted that the detailed calculations shown in Table 15 pertain only to the lower Cache Creek area, and that the safe ground water yield of the Capay Valley is shown as a single estimate. Lack of available hydrologic data precluded the derivation of safe ground water yield for Capay Valley; therefore, the safe yield was assumed to be equivalent to the average annual draft on ground water during the 6-year study period, which amounted to 7,300 acre-feet.

TABLE 15

ESTIMATED SAFE ANNUAL GROUND WATER YIELD
CACHE CREEK SERVICE AREA

(In acre-feet)

	: Indicated : average for : 6-year : study : period	: Mean, : under : present : development
<u>LOWER CACHE CREEK AREA</u>		
<u>Water Supply</u>		
Surface inflow, Cache Creek near Capay	612,800	443,200
Precipitation	<u>353,400</u>	<u>326,200</u>
Subtotal	966,200	769,400
<u>Water Outflow</u>		
Surface outflow:		
Cache Creek at Yolo	483,400	339,800
Willow Slough, winter runoff	22,000	18,400
Applied surface water	8,400	7,000
Subsurface outflow:	20,900	18,000
Exports	<u>3,700</u>	<u>4,200</u>
Subtotal	538,400	387,400
<u>Available to meet water requirements</u>	427,800	382,000
Consumptive use:		
Of precipitation	253,900	234,300
Of applied surface water	<u>54,000</u>	<u>43,000</u>
Subtotal	307,900	277,300
Safe ground water yield, lower Cache Creek area	119,900	104,700
<u>CAPAY VALLEY</u>		
Safe ground water yield (present draft on ground water)	<u>7,300</u>	<u>7,300</u>
TOTAL SAFE GROUND WATER YIELD	127,200	112,000

Ground Water Recharge in Lower Cache Creek Area

As set forth in the first of the three foregoing criteria governing safe ground water yield, the safe yield of a ground water basin is equivalent to the average annual net replenishment or recharge to the basin. Therefore, evaluation of the several components of ground water recharge in the lower Cache Creek area enables a check on the safe yield as derived in Table 15.

Water for recharge comes from several sources which are, in order of decreasing significance, deep penetration of rainfall, percolation from streams, deep percolation of excess applied surface waters, and leakage from unlined irrigation canals. Since ground water in the service area is, for the most part, unconfined, recharge can occur anywhere.

The importance of deep penetration of precipitation as a source of recharge is evidenced by the reaction of the water level in wells far removed from either percolating streams or unlined canals. These water levels rise very rapidly after heavy precipitation. Precipitation must, of course, first satisfy the requirements of depleted soil moisture and consumptive use. Recharge from precipitation was evaluated as the difference between total precipitation and the sums of consumptive use of precipitation and surface outflow resulting from precipitation.

Percolation from Cache Creek accounts for nearly all of the ground water replenishment from stream channels in the lower Cache Creek area. Cache Creek loses water from two distinct reaches of its channel; lesser amounts from below Capay Dam

downstream to the Dunnigan Cutoff, and important amounts from Moore Dam downstream to about 1.5 miles southwest of Yolo. Between the Dunnigan Cutoff and Moore Dam, Cache Creek has historically gained water. Rising water in this reach of the stream is derived from the high ground water in the Hungry Hollow area to the north. From 1.5 miles southwest of Yolo to the Cache Creek Settling Basin, Cache Creek apparently neither gains nor loses significant amounts of water.

Considerable time and effort was spent during this investigation on the determination of average annual percolation from Cache Creek between Capay Dam and Yolo. Because percolation from the reach of the creek above Moore Dam is much impaired by high ground water adjacent to the stream, only the lower reach, from Moore Dam downstream to Yolo, was seriously studied. Two different methods of computing stream flow losses from Cache Creek were attempted. In the first method, several series of measurements of stream flow were made, and the results of similar measurements by other agencies were collected. In addition, the department cooperated with the U. S. Bureau of Reclamation in rating a water stage recorder for two seasons at Stevens Bridge near the upper end of the percolating reach. Continuous records from this gage enabled a comparison with records from the U. S. Geological Survey gage at Yolo, about five miles downstream. Careful analysis of these daily records and the stream measurements showed that there is a correlation between discharge and loss. However, because of lack of measurements of discharges greater than 400 second-feet, it was judged impossible to draw a discharge-loss curve for high

water stages. Therefore this method of computing percolation from Cache Creek was not used.

In the second method, a water balance was made for Cache Creek between two existing U. S. Geological Survey gaging stations. This reach includes the previously cited two losing reaches (Capay Dam to the Dunnigan Cutoff, and Moore Dam to Yolo), and the reach from Dunnigan Cutoff to Moore Dam where rising water occurs. Independent estimates were made for the additional items of supply, which, together with the flow in Cache Creek, make up the total supply of Cache Creek. These items of supply include tributary inflow, rising water, and precipitation on about 6,000 acres of Cache Creek gravels. Independent estimates were also made for the additional items of disposal, which, with the recorded outflow of Cache Creek, make up the total disposal of Cache Creek waters. Disposal items include irrigation diversions and consumptive use by vegetation along the creek. Monthly percolation was thus inventoried by totaling all items of supply and subtracting all items of disposal. Average seasonal percolation during the 6-year period, 1953-54 through 1958-59, was computed as about 34,000 acre-feet. The following tabulation summarizes the above items of supply and disposal for both the study period and the 50-year mean period.

	Six-year study period, <u>in acre-feet</u>	Mean, in <u>acre-feet</u>
<u>Supply</u>		
Inflow in Cache Creek	613,000	443,000
Tributary surface inflow	12,000	11,000
Precipitation on Cache Creek gravels	9,000	8,000
Rising ground water	<u>1,000</u>	<u>1,000</u>
Totals	635,000	463,000
<u>Disposal</u>		
Outflow in Cache Creek	483,000	340,000
Consumptive by bank vegetation	1,000	1,000
Surface diversions	<u>117,000</u>	<u>88,000</u>
Totals	601,000	429,000
Percolation (difference)	34,000	34,000

It should be noted that 25 percent of the percolation from Cache Creek moves to the area north of the creek, thus constituting subsurface outflow instead of recharge to the lower Cache Creek area. Percolation from the smaller streams which cross the area is estimated to be small, averaging about 1,000 acre-feet a year.

Deep percolation from excess applied surface water is an important source of recharge throughout the Cache Creek Service Area, because of the magnitude of surface application and the thorough coverage of the service area by surface water supplies. The existence of a high water table in the fall season around areas of surface application is regarded as evidence for this conclusion. However, the geology and pattern of ground water recharge and extraction tend to confuse the effect of applied surface water on ground water levels. Similarly, leakage from irrigation canals contributes substantial recharge, because the

extensive coverage of the service area by the canal system of the Clear Lake Water Company includes many miles of unlined ditches. At the present time, canal losses account for about 23 percent of the total water diverted by this company. The estimated recharge from excess surface water amounts to 17,000 acre-feet per year, and the estimated recharge from percolation of canal losses amounts to 24,000 acre-feet per year.

The estimated annual recharge to ground water in the lower Cache Creek area during the 6-year study period is summarized in Table 16.

TABLE 16

ESTIMATED AVERAGE NET ANNUAL GROUND WATER
RECHARGE IN LOWER CACHE CREEK AREA
DURING SIX-YEAR STUDY PERIOD

(In acre-feet)

Source	:Ground water recharge
Deep percolation of excess applied surface water	16,900
Canal losses	24,000
Deep percolation of rainfall	66,000
Stream percolation	
Cache Creek	25,500
Minor streams	<u>1,000</u>
Total recharge	133,400
<u>Items to be subtracted</u>	
Subsurface outflow to southeast	7,300
Subsurface outflow to Putah Creek	<u>4,000</u>
Subtotal	11,300
Indicated net recharge	122,100

A comparison of Table 16 with Table 15 shows that the indicated average annual ground water recharge in the lower Cache Creek area during the 6-year study period (122,100 acre-feet) agrees closely with the safe annual ground water yield of 119,900 acre-feet. In this regard it should be emphasized that the derived ground water recharge serves only as an approximation of the safe ground water yield, and is shown only as a check thereon. Safe ground water yield, as developed in Table 15, takes into account all items of water supply and disposal and is deemed to be more accurate for that reason.

CHAPTER III. WATER UTILIZATION AND REQUIREMENTS

The water resources of the Clear Lake-Cache Creek Basin have been quite highly developed in support of the thriving irrigated agricultural economy. Ground water is pumped extensively in both the Clear Lake and Cache Creek Basins, and runoff in Clear Lake is conserved for use in the downstream Cache Creek Service Basin. This chapter considers the nature and extent of present and potential ultimate water utilization and of the requirement for additionally developed water supplies in the Clear Lake-Cache Creek Basin. Water utilization and requirements were evaluated, using data on present land use patterns and classification of irrigable lands, projected ultimate crop patterns, and estimated unit values of water use and irrigation efficiencies. These data had previously been developed during the earlier investigations of the area cited in Chapter I.

In the ensuing discussion, a clear distinction is drawn between water utilization and water requirements. The term "water utilization" refers to the consumption of applied water by vegetative growth in transpiration and building of plant tissue, and to water evaporated from adjacent soil and from water surfaces. It does not include the consumption of precipitation. The term also refers to water consumed and evaporated by municipal, industrial, and other nonvegetative types of land use. As used in this bulletin, the term "water utilization" is synonymous with the term "consumptive use of applied water".

The term "water requirements", as used in this bulletin, refers to the amount of water, exclusive of precipitation, needed

to provide for all beneficial uses and for losses incidental to such uses. It is measured as the amount of water delivered to a farmer's head gate in the case of agricultural use of water, and as the delivery to the water supply system of a community in the case of municipal and industrial use.

Present and potential ultimate water utilization in the Clear Lake-Cache Creek Basin was determined by application of appropriate factors of unit water use to the present and potential ultimate patterns of land use as determined from survey data. As stated, water utilization is evaluated herein as a measure of consumptive use by all types of development, while water requirements, on the other hand, are evaluated as delivery requirements, taking into account the losses attendant to the beneficial use of water. This latter evaluation is used as the basis for measurement of project accomplishments in Chapter IV. In determining the present and potential ultimate water requirements, due consideration was given to present agricultural, urban and industrial development, and to efficiencies in the use of water.

Certain possible nonconsumptive requirements for water, such as those for flood control, recreation, and preservation of fish and wildlife may be of varying significance in the design of works to meet supplemental requirements for water in the Clear Lake-Cache Creek Basin. In most instances, the magnitude of such nonconsumptive requirements, while small, is relatively indeterminate, and dependent upon allocations made after consideration of possible necessity or economic factors. For these reasons, water requirements for flood control, preservation of fish and wildlife, and

recreation are discussed in general terms in this chapter but not specifically evaluated.

Water Utilization

Of the presently developed waters utilized in the Clear Lake-Cache Creek Basin, about 95 percent are consumed in the production of irrigated crops. It is anticipated that irrigated agriculture will continue to predominate in the economy of the basin, and that under potential ultimate conditions, irrigation water requirements will amount to about 80 percent of the total.

Present Water Supply Development

The waters of the Clear Lake-Cache Creek Basin have been continually developed during the past century by both individuals and companies, primarily for enhancement of the agricultural economy of the basin. Throughout the area water supplies have been readily obtainable for domestic and municipal uses, primarily from ground water. Ground water has also been readily available for irrigation in most of the good agricultural areas. However, numerous problems have been encountered in attempts to develop surface water supplies, due to the erratic natural regimen of runoff, limited opportunity for storage, and competition between upstream and downstream interests for control of the water.

Clear Lake Basin. Waters of the Clear Lake Basin have been developed to a limited extent to serve irrigation, municipal, and domestic needs. Ground water comprises the principal source of water for these uses. In addition, some surface water is used by direct diversion of stream flow, storage on streams tributary

to Clear Lake, and by pumping from Clear Lake. However, development of surface water is limited by water rights controlling the use of Clear Lake as a storage reservoir for irrigation in Yolo County.

Early settlers in Big Valley, Scott Valley, and the Upper Lake area found ground water easy to develop because of high water tables in the free ground water zones and flowing artesian wells in the confined ground water zones. Many artesian wells were developed in the 1800's for domestic and irrigation use. However, increased water demands of recent times have so lowered the ground water tables that few artesian wells flow at present. In 1953, it was determined that there were 195 irrigation wells with motors larger than 5 horsepower in Big Valley, 11 in Scott Valley, and 18 in the Upper Lake area.

The major surface diversions in the Clear Lake Basin are made from Clear Lake to serve the Edmands and Helms Reclamation Districts, located in the Upper Lake area adjacent to Clear Lake. Here a system of canals and ditches delivers water to irrigated land which has been reclaimed from the lake by levees. Individually-owned pumps raise the water from sloughs for irrigation. Drainage pumps, operated by the reclamation districts, expel excess winter water and overflow from Scott Creek and unconsumed irrigation water into Robinson Slough, which drains into Clear Lake.

Municipal and domestic water is obtained primarily from wells. The town of Lakeport maintains the largest single municipal system, pumping about 400 acre-feet per year from two wells, or filter galleries, located in the bed of Scott Creek. This source was seriously impaired by low water conditions during 1959, and had

to be augmented by an emergency connection to an irrigation well in nearby Scott Valley. In addition to the wells used by most towns and industries in the Clear Lake Basin some communities, resorts, and individuals make use of water pumped directly from Clear Lake.

Cache Creek Basin Surface Water Development. The Cache Creek Basin has an interesting history of water supply development. The excellent potential of its agricultural lands was recognized by early settlers and the lands were put to use for production of dry-farmed grains. The settlers also recognized California's peculiar natural water supply pattern and the need for irrigation to successfully grow summer crops.

The diversion of water from Cache Creek into the Moore ditch, in 1885, marked one of the earliest water supply developments specifically for irrigation in California. This was followed by construction of the Capay Valley ditch, which diverted water from the south bank of Cache Creek above the town of Rumsey, and the Adams ditch, which diverted from the north bank of the creek near the town of Capay. Both of these latter diversions were upstream from the Moore diversion, and considerable litigation grew out of competition between the upper and lower users for the low summer flows of Cache Creek. With exception of the Capay Valley ditch, which is operated by the Rumsey Water Users Association, all of these facilities and water rights were acquired by the Yolo County Consolidated Water Company in 1903. The system was then expanded by construction of the Winters Canal.

As development progressed and water demands increased, it became evident that storage of winter runoff would be required

to augment low summer flows. The Yolo Water and Power Company acquired the system in 1911, and appropriated water from Clear Lake by construction and operation of storage control works. It is reported that this company completed construction of a concrete dam at the outlet of Clear Lake in 1914, and began releases of water for irrigation in 1916. In 1927, the rights and properties of these former companies were acquired by the Clear Lake Water Company, which has been operating the system since that time. Locations of the foregoing facilities are shown on Plate 10, entitled "Present Water Service Agencies".

Operation of Clear Lake by the Clear Lake Water Company is limited by the Gopcevic Decree to 314,000 acre-feet of storage capacity, between elevations of zero and 7.56 feet on the Rumsey Gage. Elevation zero on the Rumsey Gage corresponds to 1,318.59 feet above sea level, U. S. Geological Survey datum. As previously stated, a copy of the Gopcevic Decree is included in Appendix A.

The Clear Lake Water Company provides irrigation water service to about 20,000 acres in Yolo County. Diversions from Cache Creek, including water released from Clear Lake as well as unregulated runoff, averages about 101,000 acre-feet annually. However, the amount of water available for diversion is quite variable, and diversions have ranged from as low as 13,000 acre-feet to as high as 189,000 acre-feet per year. Table 17 summarizes the annual releases of water from Clear Lake and diversions from Cache Creek by the Clear Lake Water Company for the period from 1929 through 1958.

TABLE 17

RECORDED AND ESTIMATED ANNUAL
DIVERSIONS FROM CACHE CREEK
BY CLEAR LAKE WATER COMPANY

(In acre-feet)

Calendar year	: Water : released : from : Clear : Lake (1)	: Water : diverted : from : Cache : Creek	::	Calendar year	: Water : released : from : Clear : Lake (1)	: Water : diverted : from : Cache : Creek
1929	(2)	46,900		1946	187,900	189,000
1930	(2)	92,600		1947	33,300	37,900
				1948	81,700	104,200
1931	(2)	13,300		1949	120,700	127,100
1932	(2)	50,100		1950	88,900	92,600
1933	(2)	20,000				
1934	(2)	48,900		1951	149,700	154,300
1935	(2)	62,500		1952	141,700	149,600
				1953	(2)	138,400
1936	(2)	135,400		1954	128,000	134,800
1937	140,500	122,700		1955	110,600	119,600
1938	108,700	119,400				
1939	41,200	52,300		1956	661,500	111,800
1940	97,700	100,200		1957	108,100	101,500
				1958	60,300	95,300
1941	79,500	108,800				
1942	112,300	120,000				
1943	155,700	155,600		30-year		
1944	101,100	100,300		average		101,400
1945	146,600	137,600				

(1) Includes releases other than irrigation
in some years.

(2) Record not available.

Ground Water Development, Cache Creek Service Area.

Records of ground water development in the Cache Creek Service Area date back to at least 1877. In 1900, 12 wells were reported to have been in use, and by 1912-13 about 50 wells were being used for irrigation. Since the early 1900's, ground water development has proceeded rapidly, stimulated by the arrival of electric power and the occasional uncertainty of

surface water supplies. After World War II, a large increase in the number of wells occurred, caused by the high value of crops and the availability of large equipment, such as land levelers, which made feasible the irrigation of additional land.

Agricultural pumping comprises the largest use of ground water in the Cache Creek Service Area. About two-thirds of the irrigated lands are served by water pumped from underlying ground water storage. Ground water is pumped throughout the service area; however, lands served by ground water are interspersed within the area served by the Clear Lake Water Company, and, in some cases, lands are irrigated from both surface and ground water supplies. Pumping of ground water is most concentrated in the area east of the Plainfield Ridge. All of the water used for municipal, industrial, and domestic purposes is obtained from this source, and the heaviest use for these purposes occurs in Woodland and Davis.

During the current investigation, estimates were made of the amount of ground water pumped for irrigation within the Cache Creek Service Area during each of the four years from 1955-56 through 1958-59. The estimates were based upon Pacific Gas and Electric Company records of sales of electric power for agricultural pumping and records of pump tests. From the pump test data, values of kilowatt-hours of electric energy required to pump one acre-foot of water were determined and averaged for the subdivisions considered.

Table 18 shows electric power consumption in millions of kilowatt-hours and the estimated ground water withdrawals in acre-feet. The estimates show that ground water pumping dropped from

Sprinkler irrigation
in Cache Creek
Service Area



E. E. Luhdorff Co.,
Woodland, photograph



Farm near Woodland
prepared for ground
water irrigation

Department of Water
Resources photograph

222,000 acre-feet in 1955-56 to 181,000 acre-feet in 1958-59, and that the 4-year average was 195,000 acre-feet. It was also estimated from information collected for the Putah Creek Cone Investigation that, based on records of electric power consumption, 230,000 acre-feet of water were pumped in 1953-54, for irrigation within the Cache Creek Service Area.

TABLE 18

ESTIMATED GROUND WATER WITHDRAWAL
IN CACHE CREEK SERVICE AREA
BASED ON ELECTRIC POWER SALES

Season (April 1 to March 1)	Davis Sub- division (1)			Winters Sub- division (1)			Woodland Sub- division (1)			Total		
	Ground :			Ground :			Ground :			Ground :		
	Electric power, in million KWH(2)	water with- drawal, in acre- feet	Electric power, in million KWH(2)	water with- drawal, in acre- feet	Electric power, in million KWH(2)	water with- drawal, in acre- feet	Electric power, in million KWH(2)	water with- drawal, in acre- feet	Electric power, in million KWH(2)	water with- drawal, in acre- feet	Electric power, in million KWH(2)	water with- drawal, in acre- feet
1955-56	6.65	44,000	7.99	55,000	14.49	121,000	29.13	222,000				
1956-57	5.92	39,000	6.39	44,000	12.75	106,000	25.06	190,000				
1957-58	7.03	47,000	6.70	46,000	11.79	98,000	25.52	191,000				
1958-59	7.06	47,000	5.99	41,000	11.12	93,000	24.17	181,000				
Average	6.67	44,000	6.77	46,000	12.54	104,000	25.98	195,000				

(1) Subdivisions correspond to portions of Pacific Gas and Electric Company electric service subdivisions within the Cache Creek Service Area.

(2) Electric power consumption from Pacific Gas and Electric Company records of PA-1, agricultural power, sales. Does not include municipal, industrial or domestic service.

Land Use

As a first step in estimating water utilization in the Clear Lake-Cache Creek Basin, field surveys and office compilations were made of the nature and extent of present land use, as related to use of water. Similarly, the probable nature and potential extent of ultimate land use was forecast, on the basis of land classification survey data which segregated lands in accordance with their suitability for irrigated agriculture and other uses.

Present Land Use. Present patterns of land use were determined for both the Clear Lake and Cache Creek Basins, on the basis of comprehensive land use surveys conducted in Lake County in 1953, published in Bulletin No. 14, and conducted in 1954 and 1955 during the Northeastern Counties Investigation, the results of which are published in Bulletin No. 58. In this regard, the Clear Lake Basin embraces essentially the same area as Hydrographic Unit No. 30, as published in Bulletin No. 58. Data obtained from these land use surveys, adjusted to reflect the decrease in acreage of rice since that time, and the corresponding increase in acreages of truck and field crops, are considered to represent "present" conditions of land use in the Clear Lake-Cache Creek Basin. Results of the surveys, as adjusted, are presented in Table 19. Present land use in the basin is shown on Plate 11, entitled "Classification of Lands for Water Service".

Land use within the Cache Creek Service Area is shown in Table 19 under four subdivisions or units, designated the "Capay Valley Unit", "Hungry Hollow Unit", "Winters Unit", and the "Moore Unit". The latter three units constitute a further subdivision of the lower Cache Creek area referred to in Chapter II.

These units are delineated on Plate 1. They were established to facilitate evaluation of water utilization and requirements, and will be referred to in subsequent discussion herein.

TABLE 19

PRESENT LAND USE WITHIN
CLEAR LAKE-CACHE CREEK BASIN

(In acres)

Land use	Clear Lake Basin				Cache Creek Service Area			
	: Big : Valley :	: Scott : Valley :	: Upper : Lake :	: Remaining : areas :	: Capay : Valley : Unit :	: Hungry : Hollow : Unit :	: Winters : Unit :	: Basin : Totals :
	Valley	Valley	Lake	areas	Totals	Unit	Unit	Totals
<u>IRRIGATED CROPS</u>								
<u>Major Irrigation Season</u>								
Orchard	4,210	660	520	790	6,180	670	270	6,580
Alfalfa	560	200	1,330	260	2,350	410	1,740	20,010
Pasture	1,340	150	1,010	2,670	5,170	380	1,490	10,820
Truck	0	0	0	0	0	0	910	15,990
Field	20	130	540	120	810	70	4,730	11,870
Rice	0	0	0	0	0	0	7,320	12,500
Citrus and sub-tropical	0	0	0	0	0	0	6,000	8,000
Vineyard	720	10	20	0	750	0	210	1,000
Totals, major irrigation season	6,850	1,150	3,420	3,840	15,260	1,530	6,400	23,060
<u>Minor Irrigation Season</u>								
Truck	0	0	0	0	0	0	0	900
Field	0	0	0	0	0	0	0	500
Totals, minor irrigation season	0	0	0	0	0	0	0	2,600
URBAN	720	50	440	440	1,650	0	0	1,500
								2,740
								4,390

The most significant development and use of land within the Clear Lake Basin is concentrated in the valley floor areas adjacent to Clear Lake. Extensive areas of agricultural lands are irrigated in Big Valley, Scott Valley, and the Upper Lake area around the westerly portion of Clear Lake. The lands presently (1955) irrigated within those areas, amounting to 11,430 acres, comprise 75 percent of the total irrigated lands (15,260 acres) in the basin. The principal irrigated crop is deciduous orchard, consisting mainly of pears and walnuts. Other leading crops are pasture and alfalfa, with smaller amounts of field and vineyard crops.

Irrigation development is confined principally to Big Valley, Scott Valley, and the Upper Lake area because firm water supplies can be obtained from the underlying ground water basins. The remaining irrigated areas also rely on ground water, and to some extent on diversions from streams. In addition to the irrigated areas, about 16,000 acres in Big Valley, Scott Valley, and the Upper Lake area sustain a dry-farmed economy of orchard, pasture, and field crops. In many instances, the dry-farmed orchards are on hillside lands not feasible of irrigation from ground water supplies.

The irrigated lands, as surveyed in the Cache Creek Service Area in 1955, amounted to 69,440 acres. The most widely planted crop at that time was alfalfa with 20,000 acres, followed by rice with 14,300 acres. However, during the period since 1955, there has been a marked decrease in the acreage of rice grown in the service area. The decrease is attributed to such factors as governmental controls on rice acreages, excessive amounts of water

Orchard lands in
Clear Lake Basin



ABOVE:
Young and old
almond trees in
bloom near Clear
Lake Oaks

LEFT:
Young walnut
orchards on
hill lands south
of Mt. Konoti

required to raise rice on the soils in the service area, cost of water from both surface and underground sources, and the opportunity for greater income from truck and field crops such as tomatoes and sugar beets.

It was estimated that the rice acreage in the Cache Creek Service Area had decreased in 1959 to only 2,300 acres. It was further estimated that the average rice acreage during the 6-year study period was 8,000 acres, which acreage was considered to represent "present" rice irrigation. The decrease from the 1955 level of rice irrigation was considered to be divided equally between truck crops and field crops. With respect to rice, truck, and field crops, the figures shown in Table 19 reflect the adjusted values, which are considered to represent the average crop pattern during the 6-year study period.

Potential Ultimate Pattern of Land Use. As previously stated, lands in the Clear Lake-Cache Creek Basin were classified during previous investigations with respect to their suitability for irrigated agriculture. As part of the Northeastern Counties Investigation, the location and extent of all irrigable lands were determined by field surveys which grouped the lands into their appropriate classifications of irrigability and crop adaptability. During those surveys, considerable emphasis was placed upon the classification procedure and the projection of the potential ultimate crop pattern. Both of these considerations are significant in determining the water requirements to be used in water project planning studies, and the agricultural benefits to be used for economic analysis of water projects.

The suitability of land for irrigation development is influenced by many factors. Physical characteristics and topography of the land, as well as characteristics of the soil itself, such as texture, depth, and structure, directly affect adaptability of the land for irrigation development. Further, the location of the land with respect to the available water supply affects the degree of possible development through irrigation. Some of the indirect factors are climatic conditions and the production and marketing of climatically adapted crops. For the Clear Lake-Cache Creek Basin Investigation, all pertinent factors, direct and indirect, were considered in projecting future requirements for water. Lands classified as suitable for irrigation development were segregated into three broad topographic groups; smooth-lying valley lands, slightly sloping and undulating lands, and steeper and more rolling lands. Where other conditions limited the suitability of the lands to produce climatically adapted crops, the three broad classes were further subdivided in accordance with the nature of the limitations. Such limiting conditions included shallow soil depths, rockiness, high-water tables, coarse textures with low moisture-holding capacities, very fine textures limiting the effective depth, and the presence of saline and alkaline salts.

A summary of results of the land classification is presented in Table 20, which shows the three general categories of irrigable lands and other principal land use classes, by units of the Clear Lake-Cache Creek Basin.

TABLE 20

(In acres)

Classification	Clear Lake Basin	Cache Creek Service Area				Totals
		Capay Unit	Hungry Hollow Unit	Winters Unit	Moore Unit	
Irrigable valley lands	45,220	5,815	12,541	81,742	38,872	138,970
Irrigable hill lands	22,620	560	49	2,915	633	4,157
Irrigable steep hill lands	17,750	0	0	1,449	0	1,449
Total, gross irrigable lands	85,620	6,375	12,590	86,106	39,505	144,576
Urban land (1955)	1,650	0	0	1,060	1,676	2,736
Industrial land (1955)	0	0	0	0	22	22
Nonirrigable land	<u>522,330</u>	<u>23</u>	<u>1,626</u>	<u>2,042</u>	<u>985</u>	<u>4,676</u>
TOTAL AREA	609,600	6,398	14,216	89,208	42,188	152,010

1/ Does not include nonirrigable portions of drainage areas above valley floor.

Even in the most intensively developed areas of irrigated agriculture, not all of the irrigable lands receive water every year. Since results of the land classification survey were in terms of gross areas, it was necessary to determine the net acreage that might ultimately be irrigated in any one year. This will depend on one or more of the following factors:

1. Quality of the Land and Crop Rotation. (Higher quality lands tend to be intensively developed for continuous irrigation, with the best farming practices. Poorer quality lands are apt to be in production only under favorable economic conditions. Some lands in all irrigated areas lie fallow each year.)

2. Irrigable Areas Utilized for Purposes Other Than Agriculture. (Urban development, farm lots, highways, railroads, canals, and industrial sites.)

3. Inclusions of Nonirrigable Land. (Usually the occurrence of nonirrigable areas is greatest in the marginal classes.)

4. Size, Shape, and Location of Irrigable Land. (Small irregular plots cannot be as completely developed as large compact units. Further, land in small ownerships is not as subject to intensive development as in large ownerships.)

5. Ease of Development. (Smooth valley lands are more subject to intensive development than lands with adverse topographic or soil conditions.)

In projecting the potential ultimate land use in the Clear Lake-Cache Creek Basin, consideration was given to the present irrigation development, to recent trends in cropping practices, and to probable trends of urban encroachment upon agricultural areas. County farm advisors and leaders in agriculture throughout the basin furnished valuable information to aid in the forecast of future agricultural development. The potential ultimate land use pattern, so determined, is presented in Table 21.

TABLE 21

POTENTIAL ULTIMATE LAND USE PATTERN
WITHIN CLEAR LAKE-CACHE CREEK BASIN

(In acres)

Land use	Clear Lake Basin									
	Big	Scott	Upper	Remaining	Capay	Hungry	Winters	Moore	Basin	Totals
	Valley	Valley	Lake	areas	Totals	Unit	Unit	Unit	Unit	Totals
<u>IRRIGATED CROPS</u>										
Major Irrigation Season										
Orchard	8,300	1,120	1,770	17,510	28,700	3,300	100	11,600	2,000	17,000
Alfalfa	730	220	1,620	10,430	13,000	1,400	1,900	9,400	3,100	15,800
Pasture	2,960	250	2,800	14,890	20,900	200	100	3,500	1,200	5,000
Truck	a	a	a	600	600	400	4,300	22,600	5,200	32,500
Field	2,780	670	2,280	270	6,000	500	5,200	20,000	6,300	32,000
Totals, major irrigation season	14,770	2,260	8,470	43,700	69,200	5,800	11,600	67,100	17,800	102,300
Minor Irrigation Season										
Truck	0	0	0	0	0	0	1,700	8,500	2,300	12,500
Field	0	0	0	0	0	0	1,000	5,000	1,100	7,100
Totals, minor irrigation season	0	0	0	0	0	0	2,700	13,500	3,400	19,600
URBAN	2,000	100	700	5,600	8,400	0	0	9,500	17,000	26,500

a - Truck crops combined with field crops.

In connection with Table 21, and in subsequent discussion throughout this bulletin, the term "ultimate" should be defined. As used, the term refers to conditions after an unspecified but long period of years in the future when development of the land and water resources will be essentially stabilized.

Because of the present intensive development within the Cache Creek Service Area, and the anticipated rapid increase if additional water supplies are made available, it was considered that ultimate development will have been essentially attained within the next 50 years or so. In consideration of this assumed development period, and of the 50-year period adopted for analysis of proposed water development projects discussed in Chapter IV, the year 2015 was chosen as representative of ultimate development in the Cache Creek Service Area. However, in the Clear Lake Basin the rate of development was not projected, and the time at which ultimate conditions may be attained was not designated.

It may also be noted in Table 21 that irrigated lands in the Cache Creek Service Area are shown under the general categories of "major" and "minor" irrigation season. The major irrigation season extends from April through October, the growing season of the primary agricultural crops. The minor irrigation season covers the fall months of September and October and the spring months of March and April, during which months irrigation supplements winter rainfall in the production of field and truck crops in the areas subject to double cropping. At present, there is a trend toward double cropping in the service area, to the extent that in 1955 an estimated 4,100 acres were so planted. It is expected that this practice will increase, and that ultimately about 20 percent of the

irrigated area will be double cropped. It is forecast that 20,000 acres will be subject to double cropping (for example, winter planting of spinach following the fall harvesting of tomatoes) in the Cache Creek Service Area.

It is believed that in the Clear Lake Basin deciduous orchard will remain one of the significant crops. Pears and walnuts, because of their suitability to the climate and soils, could be increased to about 29,000 acres. It is anticipated that with the development of dependable water supplies there would be extensive increases in the acreages of alfalfa and pasture to support livestock. The predicted acreages of alfalfa and pasture are 13,000 and 21,000 acres, respectively. Other smaller areas would be devoted to grain, hay, truck, and field crops, for a total net irrigated area of some 69,000 acres.

Most of the irrigable lands in the Cache Creek Service Area are of high quality with few physical limitations. Of the 145,000 acres classified as gross irrigable area, the maximum net irrigable area was estimated to be about 129,000 acres. However, after taking into account estimated future expansion of urban areas, the actual net irrigable area probably will not exceed 118,000 acres. The potential ultimate (2015) crop pattern was projected for the latter figure.

The projected potential ultimate crop pattern within the Cache Creek Service Area for the major irrigation season would consist of 38,000 acres of truck crops and 37,000 acres of field crops, comprising about one-half of the irrigated area. Deciduous orchards would double from the present acreage to 14,000 acres. The area planted to alfalfa would increase only slightly to 24,000

acres, and pasture would decrease to about 5,000 acres. No rice was included in the ultimate crop pattern. The selection of these crop acreages and distribution was influenced by both the suitability of crops to land types and the payment capacity of various crops. With the prospect of more intensive farming, crops having relatively high water requirements and with a marginal ability to pay are not expected to compete favorably with crops providing greater returns.

Urban growth will be of considerable significance in the Cache Creek Service Area. Population within the service area is expected to increase from 25,000 at the present time (1955) to some 205,000 by 2015. The City of Woodland is expected to experience a corresponding increase in areal extent from the present (1955) area of 1,800 acres to an area of 14,000 acres by 2015. The remaining urban areas, principally Davis, and including the smaller communities of Winters and Esparto, are similarly expected to grow from a present total area of 1,000 acres to some 12,500 acres by 2015. Because of the highly developed agricultural lands, particularly adjacent to Davis and Woodland, urban expansion will replace irrigated agriculture to a considerable extent.

The projected rate of increase in irrigated and urban areas in the Cache Creek Service Area, by decades, from the present (1955) to 2015 is shown in Table 22. The effect of the encroachment of urban development upon irrigated lands beyond 1975 is quite evident. Table 22 also shows that the service area will be nearly fully developed by 1975.

TABLE 22
ESTIMATED NET IRRIGATED AND URBAN AREAS
IN CACHE CREEK SERVICE AREA
BY DECADES FROM 1955 TO 2015

(In acres)

Year	Irrigated lands		Urban	Total
	Major irrigation season	Minor irrigation season*		
1955	69,400	4,100	2,800	76,300
1965	60,600	5,400	4,400	70,400
1975	118,000	12,100	6,400	136,500
1985	115,900	14,800	9,600	140,300
1995	112,100	17,200	14,300	143,600
2005	107,600	19,300	20,000	146,900
2015	102,300	19,600	26,500	148,400

* Area irrigated during minor irrigation season represents double cropping on lands also used during major irrigation season.

Unit Use of Water

The second step in evaluation of water utilization and requirements involved determination of unit values of water use for each of the major types of land use in the Clear Lake-Cache Creek Basin. In general, unit values of water use for irrigated agriculture had been developed in past investigations of the basin.

Values of unit use of water, as discussed and presented in this section, are of two types, determined on separate but closely related bases. The first type of unit use is the consumptive use of applied water, or the quantity of surface or ground water actually consumed by the particular type of land use to which

such water is applied. Unit consumptive use of applied water serves as the basis for determining the area of irrigated and urban lands that can be sustained by a given water supply, both surface and underground, provided the service area overlies an unconfined ground water basin. This latter holds for the entire Cache Creek Service Area and for the bulk of the irrigated areas in the Clear Lake Basin.

The second type of unit water use considered in this section concerns the application of water, and it includes in addition to actual consumptive use of applied water, the losses of water during application. Nearly all of these losses are involved in the irrigation of crops. In the Cache Creek Service Area and in the majority of irrigated area in the Clear Lake Basin, these application losses percolate to ground water and are available for re-use. Unit values of applied water were used as the basis for determining the area that can be served with surface water from water development projects to be evaluated in Chapter IV.

Unit values of consumptive use of applied water for Big Valley, Scott Valley, and the Upper Lake area of the Clear Lake Basin were taken from Department of Water Resources Bulletin No. 14. These values were derived during a study by the Soil Conservation Service of the U. S. Department of Agriculture, in 1953, in co-operation with the Department of Water Resources. The estimates were based upon the Blaney-Criddle method of analysis, which correlates measured values of consumptive use of water by representative crops with climatic data. Unit values of consumptive use of applied water for portions of the Clear Lake Basin not covered by the foregoing study were taken from Bulletin No. 58.

These values also were based upon the Blaney-Criddle method of estimation, as presented in State Water Resources Board Bulletin No. 2, "Water Utilization and Requirements of California".

The unit values of consumptive use of applied water for the Cache Creek Service Area were used as published in Bulletin No. 20. These values were estimated from direct measurements of consumptive use for crops grown on the University of California at Davis, and from correlations of the resulting data with climatological factors.

In all cases, estimates were prepared separately for irrigated alfalfa, improved pasture, rice, and vineyards. However, the categories of deciduous orchard, truck, and field crops each represent a group of crops with unit consumptive use values so similar as not to justify their separate evaluation. Deciduous orchard includes almonds, walnuts, pears, apricots, and prunes. Truck crops include tomatoes and other vegetable crops. Field crops include safflower, sugar beets, field corn, and sorghums. The unit values for each category were determined by preparing estimates for each crop from available data, and by averaging these values in accordance with the acreage of each crop.

Unit values of urban consumptive use of applied water were determined from individual data for the City of Woodland and combined data for Davis, Winters, and Esparto. These values were based on a present (1959) daily per-capita consumption of 400 gallons in Woodland and 250 gallons in the remaining communities. It is estimated that increasing population densities, combined with increasing per-capita water consumption due to the greater use of automatic household utilities, will result in a 25 percent increase in unit urban water requirements by 2015.

Estimated unit values of consumptive use of applied water by irrigated crops and by urban areas in the Clear Lake-Cache Creek Basin are presented in Table 23.

TABLE 23
ESTIMATED UNIT VALUES OF MEAN ANNUAL
CONSUMPTIVE USE OF APPLIED WATER
IN CLEAR LAKE-CACHE CREEK BASIN

(In feet of depth)

Land use	Clear Lake Basin		
	: Cache : Big Valley, Scott:		
	: Creek : Valley, and Upper:		
	:Service Area:	Lake area	:Remaining areas
Irrigated crops			
Orchard	1.8	1.3	1.3
Alfalfa	2.7	2.5	2.0
Pasture	3.0	2.5	2.3
Truck	1.9	0.8	0.8
Field	1.7	0.8	0.8
Rice	4.1	---	---
Vineyard	1.4	1.3	1.4
Urban area			
Present	1.0	0.6	0.6
Ultimate	1.3	0.8	0.8

Estimated unit values of applied water, measured as farm delivery requirements for surface supplies and as gross pumpage for ground water supplies, are set forth in Table 24. The farm delivery requirements in the Cache Creek Service Area were derived by dividing the unit consumptive use of applied water by the irrigation efficiency. The term "irrigation efficiency" refers to the ratio

of the consumptive use of applied water to the total application of water, expressed as a percent. An irrigation efficiency of 70 percent was adopted for this investigation, based upon information furnished by the office of the Yolo County Farm Advisor.

With respect to the Clear Lake Basin, unit values of applied water were developed for Big Valley, Scott Valley, and the Upper Lake area, from field records collected during the Lake County Investigation during the period from 1949 through 1952. Unit values for the remainder of the present and potential water service areas were taken from Bulletin No. 58, and were based upon an irrigation efficiency of 60 percent.

TABLE 24

ESTIMATED UNIT MEAN ANNUAL VALUES OF
APPLIED WATER FOR PRINCIPAL LAND USES
IN CLEAR LAKE-CACHE CREEK BASIN

(In feet of depth)

Land use	:	:	Clear Lake Basin	
			Big Valley, Scott :	Valley, and Upper :
	Cache Creek		Valley, and Upper :	
	Service Area		Lake area	Remainder .
Irrigated crops				
Orchard	2.6		2.3	2.2
Alfalfa	3.9		4.0	3.3
Pasture	4.3		3.0	3.8
Truck	2.7		2.0	1.3
Field	2.5		1.7	1.3
Rice	9.0		---	---
Vineyard	2.5		0.6	2.3
Urban				
Present	2.3		1.3	1.3
Ultimate	2.8		1.8	1.8

Consumptive Use of Applied Water

Water utilization in the Clear Lake-Cache Creek Basin was evaluated by multiplying the acreage of each type of land use by the appropriate unit value of consumptive use of applied water. The estimated present and potential ultimate mean seasonal consumptive use of applied water in the basin is summarized in Table 25, for irrigated and urban areas and by appropriate subdivisions of the basin. The values shown for present consumptive use of applied water represent the summation of the products of the acreages shown in Table 19 and the appropriate unit values listed in Table 23. Similarly, the potential ultimate consumptive use of applied water shown in Table 25 represents the summation of the products of the data from Tables 21 and 23.

TABLE 25

ESTIMATED PRESENT AND POTENTIAL ULTIMATE MEAN
ANNUAL CONSUMPTIVE USE OF APPLIED WATER
IN CLEAR LAKE-CACHE CREEK BASIN

(In acre-feet)

Area and unit	Present		Potential ultimate	
	Irrigated : lands	Urban : Total	Irrigated : lands	Urban : Total
<u>Clear Lake Basin</u>				
Big Valley	11,200	400	11,600	22,100
Scott Valley	1,900	0	1,900	3,200
Upper Lake area	7,000	300	7,300	15,100
Remainder	7,800	300	8,100	83,200
Totals	27,900	1,000	28,900	123,600
<u>Cache Creek Service Area</u>				
Capay Valley Unit	3,600	0	3,600	11,900
Hungry Hollow Unit	17,200	0	17,200	25,200
Winters Unit	101,200	1,100	102,300	146,700
Moore Unit	56,200	1,700	57,900	39,500
Totals	178,200	2,800	181,000	223,300
				61,200
				21,700
				34,300
				257,600

The values shown in Table 25 include the consumptive use of both surface and ground water. In the Clear Lake Basin, present water supplies are developed almost entirely from underground sources; whereas in the Cache Creek Service Area the use of surface water is substantial, although ground water serves as the primary source. In analyzing the hydrology of the latter area, particularly with respect to evaluation of safe ground water yield, the present consumptive use of ground water was estimated, utilizing records of power consumption and surface diversions, with due consideration to irrigation efficiencies and present irrigation patterns. The estimated breakdown of present mean annual consumptive use of applied water, as between ground water and surface water, is shown in the following tabulation:

	<u>Ground water</u>	<u>Surface water</u>
Clear Lake Basin	28,000 acre-feet	1,000 acre-feet
Cache Creek Service Area	142,000 acre-feet	39,000 acre-feet

Water Requirements

This section considers and evaluates the present and potential ultimate requirements for developed and delivered water at the place of use; discusses the important nonconsumptive uses of water, for control of floods and for fish, wildlife, and recreation; discusses factors affecting the delivery and application of water, and the losses incidental to such delivery and application; and evaluates the present and potential ultimate requirement for supplemental water within the Clear Lake-Cache Creek Basin.

Application of Water

As previously stated, water requirements are evaluated in this bulletin as delivery to the farmer's head gate for surface water supplies, and as gross pumpage from ground water sources. Both the head-gate delivery and gross pumpage are equivalent to the amount of applied water, and they have been so evaluated. Water requirements, as evaluated on this basis, were used in determining project accomplishments described in Chapter IV.

The estimated present and potential ultimate mean annual application of water in the Clear Lake-Cache Creek Basin is summarized in Table 26. The values shown for present application of water represent the summation of the products of the acreages shown in Table 19 and the appropriate unit values listed in Table 24. Similarly, the values shown for potential ultimate application of water represent the summation of the products of the data from Tables 21 and 24.

ESTIMATED PRESENT AND POTENTIAL ULTIMATE
MEAN ANNUAL APPLICATION OF WATER
IN CLEAR LAKE-CACHE CREEK BASIN

(In acre-feet)

Area and unit	Present water requirements				Ultimate water requirements (2015)			
	Irrigation:		Urban:		Irrigation:		Urban:	
	major	minor	season	Subtotal	major	minor	season	Subtotal
<u>Clear Lake Basin</u>								
Big Valley	16,400	0	900	17,300	35,600	0	3,600	39,200
Scott Valley	3,000	0	100	3,100	5,400	0	200	5,600
Upper Lake	10,300	0	600	10,900	22,900	0	1,300	24,200
Remaining area	<u>12,500</u>	<u>0</u>	<u>600</u>	<u>13,100</u>	<u>130,700</u>	<u>0</u>	<u>10,100</u>	<u>140,800</u>
Subtotal	42,200	0	2,200	44,400	194,600	0	15,200	209,800
<u>Cache Creek Service Area</u>								
Capay Valley Unit	5,100	0	0	5,100	17,000	0	0	17,000
Hungry Hollow Unit	27,800	0	0	27,800	32,300	3,700	0	36,000
Winters Unit	159,900	2,900	2,700	165,500	191,000	18,600	27,900	237,500
Moore Unit	<u>81,600</u>	<u>3,000</u>	<u>3,600</u>	<u>88,200</u>	<u>51,700</u>	<u>4,700</u>	<u>48,200</u>	<u>104,600</u>
Subtotal	274,400	5,900	6,300	286,600	292,000	27,000	76,100	395,100

As a check on the estimated present (1955) application of irrigation water in the Cache Creek Service Area, as presented in Table 26, records of water sales by the Clear Lake Water Company and of power sales by the Pacific Gas and Electric Company were analyzed, and tabulated by year (April 1 through March 31) for the 6-year study period. These data are shown in Table 27. The values shown for surface water sales represent actual records of water delivered to the farmer's head gate. The values shown for ground water pumpage were developed from records of sales of electric energy, in kilowatt-hours, which records were converted to pumpage of water, as described in an earlier section of this chapter.

TABLE 27
ANNUAL APPLICATION OF IRRIGATION
WATER WITHIN CACHE CREEK SERVICE AREA
DURING SIX-YEAR STUDY PERIOD

(In acre-feet)

Season : (April 1 to : March 1) :	Record of water sales : by Clear Lake Water Company:	Ground water : pumpage :	Total :
1953-54	111,000	230,000	341,000
1954-55	109,000	219,000	328,000
1955-56	87,000	222,000	309,000
1956-57	76,000	190,000	266,000
1957-58	66,000	191,000	257,000
1958-59	58,000	181,000	239,000
Average	85,000	205,500	290,000

As shown in Table 27, the recorded and computed annual application of water in the Cache Creek Service Area



Clear Lake at flood
stage of 9.96 feet
on Rumsey Gage,
April 10, 1958



ABOVE:
Municipal wharf
at Lakeport

RIGHT:
Clear Lake
Outlet Channel
at Grigsby Riffle

varied from 341,000 acre-feet for 1953-54 to 239,000 acre-feet for 1958-59, and averaged 290,000 acre-feet for the 6-year study period. The estimated present mean annual application of irrigation water is shown in Table 26 to be about 280,000 acre-feet. It should be noted that Table 27 shows actual water sales by the Clear Lake Water Company, as measured at the farm head gate. These values are substantially lower than the diversions from Cache Creek which were shown in Table 17.

The data presented in Table 27 reveal a significant recent trend within the Cache Creek Service Area. It is indicated that the application of water has decreased steadily since 1953-54. Much of this decrease may be attributed to the decrease in the area planted to rice within the service area. As previously discussed, whereas 14,000 acres of rice were included in the crop pattern surveyed in 1955, it is estimated that only about 2,000 acres were planted in 1959. Moreover, other factors, such as efforts of irrigators to use water more efficiently, and the planting of field crops that require smaller amounts of irrigation, have tended to decrease water use in the service area.

Nonconsumptive Water Requirements

As has been stated, certain nonconsumptive requirements for water, such as those for flood control, recreation, and conservation of fish and wildlife, will be of significance in the design of facilities to meet consumptive requirements in the Clear Lake-Cache Creek Basin. Except for the temporary reregulation of waters in the operation of flood control

features, the maintenance of desired water-surface levels in reservoirs for recreational purposes, and the releases of flows for the maintenance of the fisheries in Cache Creek, these purposes were considered to have no effect upon the water resources available for conservation within the basin.

Flood Control. Portions of the Clear Lake-Cache Creek Basin are subject to flood damage. Flood control projects constructed and maintained by federal, state, and local agencies have provided protection to areas in the vicinity of Upper Lake and along the lower reaches of Cache Creek. However, the flood threat still exists along the shore line of Clear Lake and in areas bordering the reach of Cache Creek between Rumsey and State Highway 99W near Yolo.

Floods in the basin occur principally from runoff of high-intensity rainstorms during winter and spring months. These floods are characterized by rapidly rising peak flows of short duration. The pattern of storms contributing to flood conditions often causes a number of peaks within a short period of time and, often, large quantities of water are produced. As reaches of the streams are relatively short and channel gradients are steep, peak flood flows usually pass completely through the basin within a 24-hour period. The effects of such floods are different for the upper and lower areas of the basin.

The shore line of Clear Lake has been subject to flooding throughout its history. The flood problem is caused primarily by the restricted outlet channel of the lake, which has a discharge capacity of about 2,500 second-feet at elevation 7.56 feet on the Rumsey Gage, and a maximum of about

Cache Creek near
Madison during flood
of February, 1958.
Note severe bank
erosion near center
of photograph



Water discharging from
Cache Creek Settling
Basin on right into Yolo
Bypass on left during
February, 1958, flood

5,000 second-feet at extreme flood stage. With historical flood inflows to the lake in excess of 40,000 second-feet, a considerable volume of flood waters must be stored temporarily in the lake. Although a dam was constructed on the outlet channel in 1914, it has not affected the channel capacity, as the impairment to flow is caused by a natural upstream restriction, the Grigsby Riffle. Water supply records indicate that the outflow capacity of the channel was less before the dam was built than at present, because of channel dredging operations. These dredging operations were halted before completion by a court suit which resulted in the Gopcevic Decree. Although the Gopcevic Decree sets the maximum flood water storage elevation in Clear Lake at 9.0 feet on the Rumsey Gage, it is not physically possible to operate within this limit with the existing restricted outlet channel. Records of water surface elevations in Clear Lake since 1874 show that elevation 7.56 has been exceeded 38 times, and that elevation 9.0 feet has been exceeded 20 times.

In February, March, and April of 1958, the elevation of Clear Lake reached a maximum of 10.88 feet and exceeded 9.0 feet for a total of 44 days. During all of this time the maximum possible release was being made from the lake. The United States Army Corps of Engineers determined that in 1958 about 4,000 acres of residential, commercial, and agricultural lands were flooded. The depth of flooding averaged about 2 feet, and water was standing in many homes and business establishments for as long as two months. Damage adjacent to Clear Lake caused by the flood of 1958, was estimated to be \$880,000.

The reach of Cache Creek downstream from Rumsey experiences flooding when the discharge of Cache Creek exceeds the channel capacity and flows over adjacent lands. Damage also occurs from bank erosion during high flows. Extensive areas of rich farm land bordering the stream have been destroyed by flood erosion. A further result of such erosion is evidenced by the rapid accumulation of silt in the Cache Creek Settling Basin, which is designed to prevent excessive amounts of silt from entering the Yolo Bypass.

The Corps of Engineers has constructed levees along the lower reach of Cache Creek from the vicinity of Yolo downstream to the settling basin. The present design capacity of 20,000 second-feet is inadequate; however, improvement of the levee system is planned. A levee break occurred during February, 1956, flooding about 700 acres. In February, 1958, the levees successfully held a peak flow of about 38,000 second-feet. However, the levees were under constant surveillance, and timely sand bagging in critical areas prevented major flooding. At the same time Cache Creek overflowed its banks upstream from the levees, flooding farm lands and Highway 99. Flood damage along the lower reach of Cache Creek during the 1958 flood was estimated by the Corps of Engineers to be about \$520,000.

The Corps of Engineers has estimated that flood control storage works on Cache Creek should be operated to limit peak discharges in Cache Creek at Capay to 21,000 second-feet. Reduction of flood flows to this amount would also eliminate the threat of damage by erosion and overflow during all but

the most severe floods. Flood control aspects of project operation are discussed in detail in Chapter IV.

Requirements for Recreation. In the current planning for comprehensive development of the Clear Lake-Cache Creek Basin, full consideration was given all beneficial uses of the water resources including recreation use and preservation and enhancement of fish and wildlife resources. Since development of the recreational potential is becoming increasingly important, emphasis was placed upon determining present levels of recreation use in the basin, the potential for future recreation enhancement, and the requirements of potential water projects in achieving the fullest development of recreational facilities.

Preliminary findings with regard to recreation in the basin were published in Bulletins No. 14 and No. 20. A more intensive study was prepared for the department in 1958 by the firm of Wilsey, Ham, and Blair, Engineers and Planners. This study comprised a survey of the recreation potential and recreation facilities in the Clear Lake Basin, and an estimate of the probable magnitude of recreation in the Clear Lake Basin in the year 2010. Estimates of future numbers of recreation user-days were included in the report, to facilitate determination of benefits accruing to potential water developments. The results of that report were utilized in the analysis of recreation benefits in the Clear Lake Basin during the current investigation. Additional work was performed during the current investigation to determine recreation potential of reservoirs proposed in this bulletin.

The Clear Lake area has been intensively developed for water-associated recreation. The lake has a shore line of 71 miles, of which 39 miles are presently developed for water-associated recreation facilities, including public and private beaches, wharfs, and lakeside residences. As an indication of the high value assigned to recreation in the area, there are approximately 11 public, 480 private, and 270 commercial water-associated recreation facilities in active use.

The report by Wilsey, Ham, and Blair indicated that approximately 2,300,000 user-days of recreation were experienced during 1958 in the Clear Lake Basin. It was further determined that about 62 percent of the recreationists come from the San Francisco Bay-Sacramento metropolitan areas, 30 percent from the remainder of Northern California, 5 percent from Southern California, 2 percent from the lower central valley, and 1 percent from out of the State.

Most of the desirable shore line locations around Clear Lake have been developed in the cited facilities. At Clearlake Highlands, the shore line is virtually saturated with recreational developments. Most of the shore line areas having access to deep waters are developed to some extent. The largest areas of undeveloped shore line exist southeast and northeast of Lakeport along shallow and marshy reaches of lake shore where, during periods of low water, the lake recedes, leaving large areas of lake bottom exposed. At the Clear Lake State Park, located at the base of Mt. Konocti on Soda Bay, a new area of public access to Clear Lake has been developed by dredging channels and lagoons for small boats.

A number of recreational facilities have been developed in the hills surrounding Clear Lake and along the tributary streams. However, the most popular resorts are those which can offer water-associated recreation. As previously indicated, there is little flow during summer months in streams tributary to Clear Lake. Many Lake County interests have indicated a desire to develop additional recreational reservoirs on these streams to maintain flow during the summer months.

At present, little recreational use is made of the main stem of Cache Creek or of its tributaries. The adjacent lands are used principally for hunting deer and quail. Even this activity is somewhat limited, owing to limited access to the lands.

In the report by Wilsey, Ham, and Blair, it was estimated that the Clear Lake-Cache Creek Basin in the year 2010 would still attract about the same proportion of recreationists to the total population as at present. It was further estimated that this level of use would exceed the possible future recreation capacity of the Clear Lake area. As a result, estimates of future use were reduced to the estimated capacity of future facilities. It was predicted that the recreational facilities could provide for 5,700,000 visitor-days in the year 2010, assuming no further development of water resources. It was pointed out that the recreational potential of Clear Lake could be definitely increased by stabilizing the surface fluctuation of the lake. This would permit additional development of many of the shallow shore line areas not now subject to use. It was estimated that the new areas to be

made useable by stabilization of the lake could provide for an additional 500,000 visitor-days of use each year at Clear Lake. Stabilization of Clear Lake would stimulate development of recreational facilities to more attractive standards than at present, as well as eliminate the present flood threat to the Clear Lake shore line.

The development of reservoirs on either Cache Creek or on the streams tributary to Clear Lake can, in most instances, be expected to attract large numbers of recreationists. This has been found to be true on all reservoirs in California where public access is provided. The future recreation potential for reservoir land in the Clear Lake-Cache Creek Basin is discussed in Chapter IV in connection with plans for water development.

Requirements for Fish and Wildlife. As part of the Clear Lake-Cache Creek Basin Investigation, a study of the probable effects of water development on fish and wildlife resources of the basin was conducted by the California Department of Fish and Game. The present fish and wildlife resources of the basin were evaluated, and features of water development proposals were considered with respect to the preservation and enhancement thereof.

Clear Lake is widely known as a good fishery for warmwater species of fish. The lake contains large numbers of largemouth bass, catfish, perch, crappie, bluegill, and sunfish. Many nongame species also inhabit the lake. Some of these rough fish, such as squawfish, suckers, splittail, and hitch, are stream spawners. These fish ascend the streams from

the lake to spawn during the spring freshets. The young usually migrate to the lake by early summer. For many years the hitch was considered as one of the most important forage species for game fish in Clear Lake. However, recent investigation by the Department of Fish and Game indicates that the hitch is of relatively minor importance to game fish production or to the economy of the Clear Lake fishery.

Limited rainbow trout fisheries are present in the upper sections of tributary streams having suitable water conditions. The Department of Fish and Game plants approximately 12,000 catchable-size rainbow trout annually in Kelsey Creek to supplement the natural fishery. Kelsey Creek is unique because it has an excellent self-sustaining brown trout (*Salmo trutta*) fishery in the middle reach of the stream above the confluence of Sweetwater Creek.

The Clear Lake area is inhabited by many species of wildlife including black-tail deer, black bear, ring-necked pheasant, mourning dove, valley quail, and rabbits. Waterfowl visit the area during migration periods. Fur-bearing animals include gray fox, bob cat, mink, raccoon, ring-tail, spotted skunk, and muskrat. Many of these fur-bearers live along or in stream courses.

The main stream of Cache Creek and its tributaries provide minor fisheries for small mouth bass and white catfish. Other warmwater game species are present in limited numbers, but contribute very little to the total sport catch. In addition, other nongame species, principally of the minnow family, squawfish, carp, and roach, are found throughout the

drainage basin. Rainbow trout are present in the head waters of North Fork of Cache Creek and its tributaries, where suitable year-round water temperatures exist. It is indicated that the heavy sediment-carrying characteristics of Cache Creek are the limiting factor on the production of game fishes in the creek. Cache Creek is fed by many mineralized streams, which further degrade productivity of the fishery.

Construction of water development projects would enhance the overall fishery resources in the Cache Creek Basin, provided that certain minimum requirements were met. The most important limiting factors relating to reservoirs would be the degree of water surface fluctuation, the elevation of the minimum pool, and the period of time for which minimum pool levels would have to be endured. Stream flow releases, in the late fall following the irrigation season, would materially assist the establishment of a successful small mouth bass fishery, and possible fisheries for white catfish and channel catfish. In this connection, the Department of Fish and Game has recommended to the State Water Rights Board, during hearings regarding applications of Yolo County to store and divert waters of Cache Creek, that minimum stream flow releases of 10 cubic feet per second be maintained between the selected storage site and Capay Dam. Furthermore, it was recommended this quantity of water shall be maintained, irrespective of any existing diversions upstream from Capay Dam.

Factors of Water Demand

The term "factors of water demand", as used in this bulletin, refers to those factors pertaining to rates, times,

and places of delivery of water, and losses of water imposed by the control, development, and use of water for beneficial purposes. Irrigation practices in the Clear Lake-Cache Creek Basin, as determined by irrigation efficiencies, monthly demands, and permissible deficiencies in application of water, must be given consideration in preliminary design of works to meet supplemental water requirements. These factors of demand are discussed in this section.

Irrigation Efficiency. As previously stated, estimates of irrigation efficiency in the Clear Lake Basin were taken from the results of the Lake County Investigation published in Bulletin No. 14. The irrigation efficiency, based on studies made by the Soil Conservation Service and published in Appendix K to Bulletin No. 14, amounted to about 55 percent. It may be recalled that irrigation efficiency is defined as the ratio of the consumptive use of applied water to the total amount of applied water, expressed as a percentage. Estimates of irrigation efficiency in the Cache Creek Service Area were taken from data furnished by the office of the Yolo County Farm Advisor, and amount to about 70 percent.

Monthly Demands for Water. Irrigation demands for water in the Clear Lake-Cache Creek Basin are seasonal in nature, being confined chiefly to the period from April through October. The maximum rate of demand occurs during the months of June and July, amounting to more than one-half of the total seasonal water requirement. On the other hand, the demand pattern for urban water is continuous throughout the season, with increases throughout the summer months for the

watering of lawns and gardens. Estimated monthly irrigation and urban demands for water in the Clear Lake-Cache Creek Basin, expressed as percentages of the seasonal totals, are presented in Table 28. The urban demands are based upon data furnished by the cities of Woodland and Davis.

TABLE 28
ESTIMATED AVERAGE MONTHLY DISTRIBUTION
OF DEMAND FOR WATER IN
CLEAR LAKE-CACHE CREEK BASIN
(In percent of seasonal total)

Month	:	Irrigation	:	Urban
January		0		4
February		0		4
March		0		4
April		2		5
May		10		12
June		21		12
July		33		16
August		15		14
September		14		11
October		4		9
November		1		5
December		<u>0</u>		<u>4</u>
Totals		100		100

Permissible Deficiencies in Application of Irrigation Water. Studies to determine deficiencies in the supply of irrigation water that might be endured without permanent

injury to perennial crops were not made in connection with this investigation. However, it has been determined from prior investigation that a maximum deficiency of 35 percent of the full seasonal requirement can be endured, if the deficiency occurs only at relatively long intervals.

In the selection of water development projects to serve the Clear Lake-Cache Creek Basin, it was assumed that a deficiency of 50 percent of the seasonal irrigation requirement could be endured in one year of the 45-year operational period. It was further assumed that requirements for urban water would be met at all times without deficiency.

Supplemental Water Requirements

The previously presented data and discussion regarding water supply and requirements in the Clear Lake-Cache Creek Basin indicate that water supply problems are limited largely to those connected with ground water in the Clear Lake Basin, and to both ground water and surface water in the Cache Creek Service Area. It is further indicated that these problems are at the present time and will in the future continue to be related primarily to irrigated agriculture. While water problems are not considered severe from an overall standpoint at the present time, the water supplies, as presently developed, will limit growth of the economy to essentially its present level, unless additional firm water supplies are made available. The estimated present and potential ultimate supplemental water requirements within the Clear Lake-Cache Creek Basin are evaluated and discussed in this section.

Present Supplemental Water Requirement. The term "present supplemental water requirement", as used herein, refers to the amount of water which must be developed over and above the present yield of local water supplies to satisfy the present water requirement. It was concluded during the Lake County Investigation (published in Bulletin No. 14) that present (1955) water requirements in the Clear Lake Basin are being fully met by ground water supplies, and that there is no present supplemental requirement. However, it was concluded during the current investigation that the Cache Creek Service Area is in need of supplemental water at the present time.

The rather thorough integration of surface and ground water irrigation in the Cache Creek Service Area, and the widely variant use from each source during any particular season, somewhat complicates the determination of the present supplemental water requirement, and necessitates the adoption of certain assumptions. With respect to surface water supplies, it was assumed that the computed average annual diversion and sales of water by the Clear Lake Water Company during the 45-year period from 1914 through 1958, had present land use prevailed during that period, represents the present firm surface supply. The annual diversions and sales during the 45-year period would have averaged 90,000 acre-feet and 72,000 acre-feet, respectively. The annual diversions and sales during the 6-year study period averaged 106,000 acre-feet and 85,000 acre-feet, respectively. While the average annual diversion during the latter period is suitable for use in computing safe ground water yield, it does not represent a firm surface supply.

Therefore, it is concluded that the present water requirements in the Cache Creek Service Area are being met not only by an overdrawn ground water supply, but by a deficient surface water supply. The present supplemental water requirement in the service area was determined as the difference between the present annual gross application of water (286,600 acre-feet) and the sum of the safe annual ground water yield (160,000 acre-feet on the basis of gross application) and the firm annual surface application (72,000 acre-feet), and amounts to 54,600 acre-feet.

The present supplemental water requirement in the Cache Creek Service Area can be further broken down as between surface and ground water from data presented heretofore. With respect to ground water, the indicated overdraft was determined as the difference between the present consumptive use of applied ground water (142,000 acre-feet) and the present safe ground water yield of 112,000 acre-feet, derived in Table 15, and amounts to 30,000 acre-feet per year, on the basis of net draft, or consumptive use of applied water. On the basis of gross application, determined by dividing the latter value by the irrigation efficiency of 70 percent, the indicated present ground water overdraft is 41,600 acre-feet. The present surface water deficiency was determined as the difference between the average annual delivery during the 6-year study period (85,000 acre-feet) and the 35-year average of 72,000 acre-feet, and amounts to 13,000 acre-feet.

For purposes of this bulletin the present annual supplemental water requirement in the Cache Creek Service Area is distributed among the hydrologic units as follows:

	<u>Ground water (acre-feet)</u>	<u>Surface water (acre-feet)</u>
Capay Valley	-1,100	0
Hungry Hollow	0	1,000
Winters	17,000	10,000
Moore	<u>25,700</u>	<u>2,000</u>
Totals	41,600	13,000

It may be noted that the Capay Valley Unit shows a negative value. This is due to the fact that the present safe ground water yield for that unit was determined as the average net draft on ground water during the 6-year study period, which amounted to 4,300 acre-feet, whereas the present net draft (Table 25) amounts to 3,600 acre-feet. Therefore, the 1955 net draft could be increased by 700 acre-feet and the gross draft could be increased by 1,100 acre-feet without exceeding the safe ground water yield.

With respect to the present supplemental water requirement in the Cache Creek Service Area, an explanation should be made concerning the relationship between the crop pattern and corresponding water requirements, adopted as "present" in this bulletin, and the actual present conditions, as of 1960. With exception of the previously discussed changes in planting of rice and truck and field crops, 1955 was selected as representing "present" conditions because that was the year of the latest comprehensive land use survey,

and it is necessary to determine water requirements on the basis of specific and detailed land use. If complete data on land use were available for 1960, the present (1960) supplemental water requirement would be somewhat less than the estimate derived herein.

However, the time base upon which the present supplemental water requirement was determined is not of particular significance. The important consideration is the determination of the future, or in this case potential ultimate (2015), supplemental requirement in the Cache Creek Service Area, which is evaluated in the ensuing section as the difference between the potential ultimate water requirement and the safe yield of surface and ground water supplies, as presently developed. The safe yield of the present water supply in the Cache Creek Service Area remains essentially constant irrespective of the cropping pattern and resultant water requirement in any particular year.

Potential Ultimate Supplemental Water Requirements.

Potential ultimate supplemental water requirements are derived herein on two bases, namely: (1) the increase in consumptive use of applied water, and (2) the increase in total water application.

Derivation on the first basis measures the ultimate increase in consumption of developed water supplies and, for the Clear Lake Basin, represents the net depletion of inflow to Clear Lake and Cache Creek from full development within the basin. Depletion from upstream development is of particular significance with respect to its effect on conservation yield of storage projects on Cache Creek. Derivation of ultimate

supplemental water requirements on the second basis measures the increase in farm delivery requirements under the potential ultimate land use pattern. Evaluation on the basis of farm delivery is of particular significance in the Cache Creek Service Area, as it enables the measurement of accomplishments of water development facilities, described in Chapter IV, which facilities would deliver water to irrigated lands throughout the service area.

The potential ultimate supplemental water requirements in the Clear Lake-Cache Creek Basin, as determined on the foregoing two bases, are presented in Table 29.

TABLE 29

POTENTIAL ULTIMATE MEAN ANNUAL
SUPPLEMENTAL WATER REQUIREMENTS
IN CLEAR LAKE-CACHE CREEK BASIN

(In acre-feet)

Area and unit	Present		Potential ultimate		Potential increase		Present supplemental		Potential ultimate
	water	requirement	water	requirement	in water	requirement	water	requirement	supplemental water
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	Consumptive:	Gross	Consumptive:	Gross	Consumptive:	Gross	Consumptive:	Gross	Consumptive:
	use of	water	use of	water	use of	water	use of	water	use of
	applied	applied	applied	applied	applied	applied	applied	applied	applied
	water	water	water	water	water	water	water	water	water
	application:	application:	application:	application:	application:	application:	application:	application:	application:
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)
	(19)	(20)	(21)	(22)	(23)	(24)	(25)	(26)	(27)
	(28)	(29)	(30)	(31)	(32)	(33)	(34)	(35)	(36)
	(37)	(38)	(39)	(40)	(41)	(42)	(43)	(44)	(45)
	(46)	(47)	(48)	(49)	(50)	(51)	(52)	(53)	(54)
	(55)	(56)	(57)	(58)	(59)	(60)	(61)	(62)	(63)
	(64)	(65)	(66)	(67)	(68)	(69)	(70)	(71)	(72)
	(73)	(74)	(75)	(76)	(77)	(78)	(79)	(80)	(81)
	(82)	(83)	(84)	(85)	(86)	(87)	(88)	(89)	(90)
	(91)	(92)	(93)	(94)	(95)	(96)	(97)	(98)	(99)
	(100)	(101)	(102)	(103)	(104)	(105)	(106)	(107)	(108)
	(109)	(110)	(111)	(112)	(113)	(114)	(115)	(116)	(117)
	(118)	(119)	(120)	(121)	(122)	(123)	(124)	(125)	(126)
	(127)	(128)	(129)	(130)	(131)	(132)	(133)	(134)	(135)
	(136)	(137)	(138)	(139)	(140)	(141)	(142)	(143)	(144)
	(145)	(146)	(147)	(148)	(149)	(150)	(151)	(152)	(153)
	(154)	(155)	(156)	(157)	(158)	(159)	(160)	(161)	(162)
	(163)	(164)	(165)	(166)	(167)	(168)	(169)	(170)	(171)
	(172)	(173)	(174)	(175)	(176)	(177)	(178)	(179)	(180)
	(181)	(182)	(183)	(184)	(185)	(186)	(187)	(188)	(189)
	(190)	(191)	(192)	(193)	(194)	(195)	(196)	(197)	(198)
	(199)	(200)	(201)	(202)	(203)	(204)	(205)	(206)	(207)
	(208)	(209)	(210)	(211)	(212)	(213)	(214)	(215)	(216)
	(217)	(218)	(219)	(220)	(221)	(222)	(223)	(224)	(225)
	(226)	(227)	(228)	(229)	(230)	(231)	(232)	(233)	(234)
	(235)	(236)	(237)	(238)	(239)	(240)	(241)	(242)	(243)
	(244)	(245)	(246)	(247)	(248)	(249)	(250)	(251)	(252)
	(253)	(254)	(255)	(256)	(257)	(258)	(259)	(260)	(261)
	(262)	(263)	(264)	(265)	(266)	(267)	(268)	(269)	(270)
	(271)	(272)	(273)	(274)	(275)	(276)	(277)	(278)	(279)
	(280)	(281)	(282)	(283)	(284)	(285)	(286)	(287)	(288)
	(289)	(290)	(291)	(292)	(293)	(294)	(295)	(296)	(297)
	(298)	(299)	(300)	(301)	(302)	(303)	(304)	(305)	(306)
	(307)	(308)	(309)	(310)	(311)	(312)	(313)	(314)	(315)
	(316)	(317)	(318)	(319)	(320)	(321)	(322)	(323)	(324)
	(325)	(326)	(327)	(328)	(329)	(330)	(331)	(332)	(333)
	(334)	(335)	(336)	(337)	(338)	(339)	(340)	(341)	(342)
	(343)	(344)	(345)	(346)	(347)	(348)	(349)	(350)	(351)
	(352)	(353)	(354)	(355)	(356)	(357)	(358)	(359)	(360)
	(361)	(362)	(363)	(364)	(365)	(366)	(367)	(368)	(369)
	(370)	(371)	(372)	(373)	(374)	(375)	(376)	(377)	(378)
	(379)	(380)	(381)	(382)	(383)	(384)	(385)	(386)	(387)
	(388)	(389)	(390)	(391)	(392)	(393)	(394)	(395)	(396)
	(397)	(398)	(399)	(400)	(401)	(402)	(403)	(404)	(405)
	(406)	(407)	(408)	(409)	(410)	(411)	(412)	(413)	(414)
	(415)	(416)	(417)	(418)	(419)	(420)	(421)	(422)	(423)
	(424)	(425)	(426)	(427)	(428)	(429)	(430)	(431)	(432)
	(433)	(434)	(435)	(436)	(437)	(438)	(439)	(440)	(441)
	(442)	(443)	(444)	(445)	(446)	(447)	(448)	(449)	(450)
	(451)	(452)	(453)	(454)	(455)	(456)	(457)	(458)	(459)
	(460)	(461)	(462)	(463)	(464)	(465)	(466)	(467)	(468)
	(469)	(470)	(471)	(472)	(473)	(474)	(475)	(476)	(477)
	(478)	(479)	(480)	(481)	(482)	(483)	(484)	(485)	(486)
	(487)	(488)	(489)	(490)	(491)	(492)	(493)	(494)	(495)
	(496)	(497)	(498)	(499)	(500)	(501)	(502)	(503)	(504)
	(505)	(506)	(507)	(508)	(509)	(510)	(511)	(512)	(513)
	(514)	(515)	(516)	(517)	(518)	(519)	(520)	(521)	(522)
	(523)	(524)	(525)	(526)	(527)	(528)	(529)	(530)	(531)
	(532)	(533)	(534)	(535)	(536)	(537)	(538)	(539)	(540)
	(541)	(542)	(543)	(544)	(545)	(546)	(547)	(548)	(549)
	(550)	(551)	(552)	(553)	(554)	(555)	(556)	(557)	(558)
	(559)	(560)	(561)	(562)	(563)	(564)	(565)	(566)	(567)
	(568)	(569)	(570)	(571)	(572)	(573)	(574)	(575)	(576)
	(577)	(578)	(579)	(580)	(581)	(582)	(583)	(584)	(585)
	(586)	(587)	(588)	(589)	(590)	(591)	(592)	(593)	(594)
	(595)	(596)	(597)	(598)	(599)	(600)	(601)	(602)	(603)
	(604)	(605)	(606)	(607)	(608)	(609)	(610)	(611)	(612)
	(613)	(614)	(615)	(616)	(617)	(618)	(619)	(620)	(621)
	(622)	(623)	(624)	(625)	(626)	(627)	(628)	(629)	(630)
	(631)	(632)	(633)	(634)	(635)	(636)	(637)	(638)	(639)
	(640)	(641)	(642)	(643)	(644)	(645)	(646)	(647)	(648)
	(649)	(650)	(651)	(652)	(653)	(654)	(655)	(656)	(657)
	(658)	(659)	(660)	(661)	(662)	(663)	(664)	(665)	(666)
	(667)	(668)	(669)	(670)	(671)	(672)	(673)	(674)	(675)
	(676)	(677)	(678)	(679)	(680)	(681)	(682)	(683)	(684)
	(685)	(686)	(687)	(688)	(689)	(690)	(691)	(692)	(693)
	(694)	(695)	(696)	(697)	(698)	(699)	(700)	(701)	(702)
	(703)	(704)	(705)	(706)	(707)	(708)	(709)	(710)	(711)
	(712)	(713)	(714)	(715)	(716)	(717)	(718)	(719)	(720)
	(721)	(722)	(723)	(724)	(725)	(726)	(727)	(728)	(729)
	(730)	(731)	(732)	(733)	(734)	(735)	(736)	(737)	(738)
	(739)	(740)	(741)	(742)	(743)	(744)	(745)	(746)	(747)
	(748)	(749)	(750)	(751)	(752)	(753)	(754)	(755)	(756)
	(757)	(758)	(759)	(760)	(761)	(762)	(763)	(764)	(765)
	(766)	(767)	(768)	(769)	(770)	(771)	(772)	(773)	(774)
	(775)	(776)	(777)	(778)	(779)	(780)	(781)	(782)	(783)
	(784)	(785)	(786)	(787)	(788)	(789)	(790)	(791)	(792)
	(793)	(794)	(795)	(796)	(797)	(798)	(799)	(800)	(801)
	(802)	(803)	(804)	(805)	(806)	(807)	(808)	(809)	(810)
	(811)	(812)	(813)	(814)	(815)	(816)	(817)	(818)	(819)
	(820)	(821)	(822)	(823)	(824)	(825)	(826)	(827)	(828)
	(829)	(830)	(831)	(832)	(833)	(834)	(835)	(836)	(837)
	(838)	(839)	(840)	(841)	(842)	(843)	(844)	(845)	(846)
	(847)	(848)	(849)	(850)	(851)	(852)	(853)	(854)	(855)
	(856)	(857)	(858)	(859)	(860)	(861)	(862)	(863)	(864)
	(865)	(866)	(867)	(868)	(869)	(870)	(871)	(872)	(873)
	(874)	(875)	(876)	(877)	(878)	(879)	(880)	(881)	(882)
	(883)	(884)	(885)	(886)	(887)	(888)	(889)	(890)	(891)
	(892)	(893)	(894)	(895)	(896)	(897)	(898)	(899)	(900)
	(901)	(902)	(903)	(904)	(905)	(906)	(907)	(908)	(909)
	(910)	(911)	(912)	(913)	(914)	(915)	(916)	(917)	(918)
	(919)	(920)	(921)	(922)	(923)	(924)	(925)	(926)	(927)
	(928)	(929)	(930)	(931)	(932)	(933)	(934)	(935)	(936)
	(937)	(938)	(939)	(940)	(941)	(942)	(943)	(944)	(945)
	(946)	(947)	(948)	(949)	(950)	(951)	(952)	(953)	(954)
	(955)	(956)	(957)	(958)	(959)	(960)	(961)	(962)	(963)
	(964)	(965)	(966)	(967)	(968)	(969)	(970)	(971)	(972)
	(973)	(974)	(975)	(976)	(977)	(978)	(979)	(980)	(981)
	(982)	(983)	(984)	(985)	(986)	(987)	(988)	(989)	(990)
	(991)	(992)	(993)	(994)	(995)	(996)	(997)	(998)	(999)
	(1000)	(1001)	(1002)	(1003)	(1004)	(1005)	(1006)	(1007)	(1008)
	(1009)	(1010)	(1011)	(1012)	(1013)	(1014)	(1015)	(1016)	(1017)
	(1018)	(1019)	(1020)	(1021)	(1022)	(1023)	(1024)	(1025)	(1026)
	(1027)	(1028)	(1029)	(1030)	(1031)	(1032)	(1033)	(1034)	(1035)
	(1036)	(1037)	(1038)	(1039)	(1040)	(1041)	(1042)	(1043)	(1044)
	(1045)	(1046)	(1047)	(1048)	(1049)	(1050)	(1051)	(1052)	(1053)
	(1054)	(1055)	(1056)	(1057)	(1058)	(1059)	(1060)	(1061)	(1062)
	(1063)	(1064)	(1065)	(1066)	(1067)	(1068)	(1069)	(1070)	(1071)
	(1072)	(1073)	(1074)	(1075)	(1076)	(1077)	(1078)	(1079)	(1080)
	(1081)	(1082)	(1083)	(1084)	(1085)	(1086)	(1087)	(1088)	(1089)
	(1090)	(1091)	(1092)	(1093)	(1094)	(1095)	(1096)	(1097)	(1098)
	(1099)	(1100)	(1101)	(1102)	(1103)	(1104)	(1105)	(1106)	(1107)
	(1108)	(1109)	(1110)	(1111)	(1112)	(1113)	(1114)	(1115)	(1116)
	(1117)	(1118)	(1119)	(1120)	(1121)	(1122)	(1123)	(1124)	(1125)
	(1126)	(1127)	(1128)	(1129)	(1130)	(1131)	(1132)	(1133)	(1134)
	(1135)	(1136)	(1137)	(1138)	(1139)	(1140)	(1141)	(1142)	(1143)
	(1144)	(1145)	(1146)	(1147)	(1148)	(1149)	(1150)	(1151)	(1152)
	(1153)	(1154)	(1155)	(1156)	(1157)	(1158)	(1159)	(1160)	(1161)
	(1162)	(1163)	(1164)	(1165)	(1166)	(1167)	(1168)	(1169)	(1170)
	(1171)	(1172)	(1173)	(1174)	(1175)	(1176)	(1177)	(1178)	(1179)
	(1180)	(1181)	(1182)	(1183)	(1184)	(1185)	(1186)	(1187)	(1188)
	(1189)	(1190)	(1191)	(1192)	(1193)	(1194)	(1195)	(1196)	(1197)
	(1198)	(1199)	(1200)	(1201)	(1202)	(1203)	(1204)	(1205)	(1206)
	(1207)	(1208)	(1209)	(1210)	(1211)	(1212)	(1213)	(1214)	(1215)
	(1216)	(1217)	(1218)	(1219)	(1220)	(1221)	(1222)	(1223)	(1224)
	(1225)	(1226)	(1227)	(1228)	(1229)	(1230)	(1231)	(1232)	(1233)
	(1234)	(1235)	(1236)	(1237)	(1238)	(1239)	(1240)	(1241)	(1242)
	(1243)	(1244)	(1245)	(1246)	(1247)	(1248)	(1249)	(1250)	(1251)
	(1252)	(1253)	(1254)	(1255)	(1256)	(1257			

CHAPTER IV. PLANS FOR WATER DEVELOPMENT

It has been shown heretofore that current water supply problems in the Clear Lake-Cache Creek Basin consist of an overdraft on ground water supplies and seasonal uncertainty in the availability of surface water supplies in the Cache Creek Service Area. The ground water overdraft, if sustained over a period of years, will result in a perennial lowering of ground water levels with resultant increase in pumping costs. The variation and nonpredictability of surface supplies results in uncertainty in the planting of annual crops and precludes the planting of many perennial crops, with resultant impairment of the agricultural economy. It has also been shown that there is a serious flood problem in areas adjacent to Clear Lake and along the main stem of Cache Creek.

It has been estimated that elimination of the present requirement for supplemental water in the Cache Creek Service Area, averaging about 55,000 acre-feet per year on a mean basis, together with provision for anticipated future growth in the area, will ultimately (2015) require the development of supplemental water in the mean annual amount of about 163,000 acre-feet on the basis of delivery requirement. It has been determined that there is no present supplemental water requirement in the Clear Lake Basin and that, in fact, the present draft on ground water could be increased slightly without incurring an overdraft condition. It has further been determined that the potential ultimate supplemental water requirement under full development of all potential water service areas in the Clear Lake

Basin would amount to 101,000 acre-feet per year on a consumptive-use basis, and 165,000 acre-feet per year on the basis of delivery requirement.

Sources of supplemental water are available locally in runoff from Cache Creek and its tributaries that presently wastes from the Clear Lake-Cache Creek Basin. While this waste, which averaged about 340,000 acre-feet per year during the mean period, would be more than adequate to fully meet the potential ultimate water requirements within the basin, it would be beyond the range of economic feasibility to develop the water resources to the extent necessary to meet those requirements. Therefore, satisfaction of the potential ultimate supplemental water requirements will necessitate the importation of water from sources outside of the basin.

It is indicated that combined operation of surface storage facilities on Cache Creek and underlying ground water storage would constitute the most economical plan of water supply development for the Cache Creek Service Area. Moreover, the operation of storage facilities on Cache Creek would enable the further utilization of water from Clear Lake, or further development in upstream reservoirs, to serve lands in the Clear Lake Basin; would provide the necessary flood protection around the perimeter of Clear Lake and along Cache Creek; and would greatly enhance recreational opportunities throughout the Clear Lake-Cache Creek Basin.

This chapter discusses and evaluates proposed plans and alternatives thereto for further development of the water resources from the Clear Lake-Cache Creek Basin, and for

importation of additional water supplies from the Sacramento River. In analyzing these plans from an economic standpoint, it is necessary to determine the amounts of water to be made available by the proposed developments and the economics of further agricultural and urban development within the basin. Discussion of various plans and of the associated considerations are presented in this chapter under the general headings: "Scope of Planning Studies", "Plans for Development in Clear Lake Basin", "Wilson Valley Project", and "Possible Alternative Plans for Water Development". With respect to the Wilson Valley Project, this chapter discussed and evaluates the conservation, recreation, and flood control benefits, and presents an analysis of the economic justification and financial feasibility.

Design of features of the plans was of a preliminary nature and primarily for cost-estimating purposes. More detailed investigation, which would be required in order to prepare construction plans and specifications, might result in designs different in detail than those presented in this bulletin. However, it is believed that such changes would not result in significant modifications of estimated cost. Structures were designed in accordance with standard engineering principles, with the objective of obtaining the most economical combination of dam embankment, spillway, and outlet works. The dams were designed to be constructed of available local materials, with consideration given to foundation conditions. Stability characteristics of the embankments were based on laboratory tests of sample materials. Spillways were sized to pass the design floods, using surcharge storage above the spillway crest to reduce peak discharges.

Project costs were based on approximate quantities estimated from preliminary designs and from estimated unit prices based on recent bids on similar projects. The costs are considered representative of those prevailing in 1959. Relocation and replacement costs were estimated on the basis of replacement in kind and of comparable utility.

Estimates of capital cost included the costs of rights of way and construction, plus 10 percent for engineering and 15 percent for contingencies. An allowance of 10 percent in addition to the estimated purchase price was allowed for property acquisition. Interest during construction was computed at a rate of 4 percent per annum for one-half of the construction period. Estimated average annual costs included interest on the capital cost at 4 percent per annum, amortization during the 50-year period on a 4 percent sinking-fund basis, general expense, and annual costs of operation, maintenance, and replacement.

Scope of Planning Studies

This section reviews planning proposals formulated within the Clear Lake-Cache Creek Basin during previous studies; outlines the scope and broad accomplishments of plans for water development resulting from the current investigation; presents an evaluation of the amounts of water that should be reserved for, or made available to, the Clear Lake Basin and the Cache Creek Service Area; and analyzes the unit benefits accruing to the delivery of water supplies and the payment capacity for the projected major irrigated crops within the basin.

Previous Planning Proposals

As briefly discussed in Chapter I, the water resources of the Clear Lake-Cache Creek Basin have been investigated in the past, and a number of water development projects have been proposed. However, these investigations generally concerned rather limited areas and the projects were of limited scope and purpose. The more significant planning proposals from these investigations are discussed in this section, with emphasis on those of particular relevance to the current investigation.

Lake County Investigation. Water development projects in the Clear Lake Basin were studied and reported upon in Department of Water Resources Bulletin No. 14, published in 1957. In that bulletin it was pointed out that the present (1955) safe ground water yield of 37,000 acre-feet per year could be increased by some 13,000 acre-feet by increasing the pumping draft thereon, thereby causing a greater lowering of ground water levels during the irrigation season and creating greater storage space to be recharged by subsequent winter runoff. Bulletin No. 14 also proposed three storage reservoirs, one on Kelsey Creek, one on Scott Creek, and one on Middle Creek.

As proposed in Bulletin No. 14, future increased water requirements in Big Valley could be met by increasing the draft on the ground water basin, which would develop an additional 9,000 acre-feet per year, and by construction and operation of Kelseyville Dam and Reservoir on Kelsey Creek, which would provide the 9,500 acre-feet per year necessary to meet the potential ultimate supplemental water requirement in that valley.

The potential ultimate supplemental water requirement in Scott Valley and local adjacent areas, amounting to 1,400 acre-feet per year, could be met by construction and operation of Lakeport Reservoir on Scott Creek. The reservoir, as proposed in Bulletin No. 14, would have a safe new yield of 7,600 acre-feet per year, of which 1,800 acre-feet were allocated to Scott Valley and the remainder of 5,800 acre-feet was allocated to Bachelor Valley, and to the Tule Lake, Helms, and Edmands Reclamation Districts.

Future water requirements in the Upper Lake area would be met by an increase in present ground water draft, thus creating additional storage space for recharge from winter flood flows, and by construction and operation of Pitney Ridge Dam and Reservoir on Middle Creek. The safe ground water yield could be increased by 4,000 acre-feet annually over the present draft, and Pitney Ridge Reservoir would develop an additional firm yield of 4,000 acre-feet per year, which would be available for surface application to irrigated lands.

Clear Lake-Cache Creek Flood Control Investigation.

Following the severe floods of 1938 the (then) Division of Water Resources, under terms of an agreement with the Counties of Lake and Yolo, made a survey of the Clear Lake-Cache Creek Basin and formulated a coordinated plan for flood control. The objective of this survey was to formulate a preliminary flood control plan which, if executed and put into operation, would afford adequate flood protection to the developments around the rim of Clear Lake and to lands and developments along the lower reaches of Cache Creek. Moreover, this plan would permit the coordinated operation

of Clear Lake and of proposed works for downstream irrigation purposes. The results of this survey are published in a document, entitled "Report on Clear Lake-Cache Creek Flood Control Investigation", February, 1939.

Briefly, the cited report proposed enlargement of the Clear Lake outlet channel to increase its capacity to 8,500 second-feet, with the lake surface at an elevation of 7.60 feet on the Rumsey Gage and with the gates open in the Clear Lake Impounding Dam. The proposed channel enlargement consisted primarily of lowering the elevation of the channel bottom, particularly through the reach comprising the Grigsby Riffle. Operation of Clear Lake in conjunction with the enlarged outlet channel would greatly reduce problems of flood damage around the lake.

The report also proposed operation of the Indian Valley and Capay Reservoirs in conjunction with an improved channel in the lower reaches of Cache Creek, which historically have been subject to flooding, to provide flood protection to the Cache Creek Basin. Indian Valley Reservoir, located on the North Fork of Cache Creek, has long been considered for storage for conservation purposes. Capay Reservoir, located on Capay Creek 5 miles upstream from the town of Capay, would have been developed for both flood control and water conservation.

Cache Creek Investigation. Under terms of the previously cited cooperative agreement with Yolo County in 1954, the Division of Water Resources undertook a comprehensive investigation of the water resources of the Cache Creek watershed, with the objective of formulating plans for solution of surface and

underground water problems and for provision of flood control. The results of this investigation were published in a document, entitled "Interim Report Cache Creek Investigation", March, 1955. The report proposed the construction of a Cache Creek project, consisting of a dam and reservoir at Guinda in Capay Valley, with 300,000 acre-feet of storage capacity, and enlargement of the Clear Lake outlet channel to a capacity of 8,500 second-feet. In the report it was stated that the project would improve the operation of Clear Lake for water conservation and flood control; would firm up annual deliveries of water to the Cache Creek Service Area to 188,000 acre-feet; would increase ground water recharge; and would provide a substantial measure of flood control in the lower Cache Creek area. The estimated total capital cost of the Cache Creek Project was estimated to be about \$14.7 million, based on 1954 price levels.

By enactment of Chapter 1950, Statutes of 1955, the Legislature adopted and authorized this general plan for development of Cache Creek, but made the express provision that no funds were to be expended on planning or construction at the Guinda site until the Wilson Valley site had been completely investigated. Pursuant to this legislation the Cache Creek Investigation was continued, but was limited to an engineering and economic comparison of the accomplishments of a project at the Wilson Valley site at a storage capacity equal to that of the authorized Guinda Project. However, additional studies were made to determine the size of the reservoir at the Wilson Valley site which would yield the maximum net benefits. The results of this investigation are published in Department of Water Resources

Bulletin No. 20, "Interim Report, Cache Creek Investigation, Comparison of Alternative Wilson Valley and Guinda Projects on Cache Creek", April, 1958. The report recommended that no further consideration be given to the Guinda Project; that the Wilson Valley Project be authorized as the next water conservation project on Cache Creek; and that an investigation be conducted to determine the financial feasibility of the Wilson Valley Project that would return the maximum net benefits.

The California Water Plan. The California Water Plan, published as Department of Water Resources Bulletin No. 3 in 1957, would have a profound effect on the Clear Lake-Cache Creek Basin, with respect to both local and statewide developments. Local developments contemplated in Bulletin No. 3 include dams and reservoirs at the Pitney Ridge site on Middle Creek, at the Lakeport site on Scott Creek, and the Kelseyville and Boggs sites on Kelseyville Creek, at the Excelsior site on Copsey Creek, at the Indian Valley site on North Fork Cache Creek, and at the Bear Valley site on Bear Creek. The first five mentioned dams and reservoirs would serve the Clear Lake area; Indian Valley Reservoir would serve Capay Valley and the lower Cache Creek area; and the Bear Valley Reservoir would be for recreation purposes.

With respect to statewide water development facilities, Bulletin No. 3 contemplates the development and diversion of waters of the Eel River by means of a tunnel and conduit into Clear Lake, a short diversion tunnel from Cache Creek to Putah Creek, and a series of reservoirs and powerplants along Putah Creek. Export of Eel River water to the Sacramento Valley by way of Clear Lake would be contingent upon enlargement of the present

outlet of the lake to minimize fluctuation of the water surface. With such enlargement, the lake level could be stabilized and local flood problems around the lake would be greatly reduced. Moreover, the Eel River diversion would substantially improve the mineral quality of the water in the lake.

Conveyance of Eel River water from Clear Lake to the floor of the Sacramento Valley by way of Cache Creek was considered in Bulletin No. 3 as a possible alternative to the Putah Creek Plan. The alternative development would consist of a series of dams and powerplants down the course of Cache Creek, very similar to the Putah Creek system, and would include the Wilson Valley Reservoir, Blue Ridge Reservoir, and Guinda Reservoir on Cache Creek.

It should be pointed out that The California Water Plan is not a construction proposal, and that the facilities described in Bulletin No. 3 represent only one means believed practicable of developing and transferring California's water resources to meet potential ultimate requirements throughout the State.

Studies by the U. S. Corps of Engineers. The Corps of Engineers investigated the Clear Lake-Cache Creek Basin during the latter 1940's to determine possible methods of solving water problems, particularly the flood problems, of the basin. In a document entitled "Review Report on Cache Creek Basin California", July, 1950, the Corps of Engineers proposed a 250,000 acre-foot reservoir at the Indian Valley site on the North Fork of Cache Creek, a 40,000 acre-foot reservoir at the Kelseyville site on Kelsey Creek, channel improvements on Middle and lower Scott Creeks, a new channel for diverting flood flows of Clover Creek,

and enlargement of the Clear Lake outlet channel. Other sites such as the Blue Ridge and Wilson Valley sites on Cache Creek, and several small reservoirs on tributaries to Clear Lake, were also studied.

As proposed by the Corps of Engineers, the Clear Lake outlet channel would be enlarged to a capacity of 8,000 second-feet, thereby enabling an improved operation of Clear Lake for flood control purposes. All of the proposed reservoirs would be operated to provide flood control and conservation of water primarily for irrigation. In addition, all of the proposed facilities, but primarily the enlarged Clear Lake outlet and Indian Valley Reservoir, would enhance recreation.

Studies by U. S. Bureau of Reclamation. The Bureau of Reclamation has studied plans for development of the water resources of the Clear Lake-Cache Creek Basin as a part of "The Comprehensive Plan for Central Valley Basin California", dated May, 1947. The bureau contemplated that the runoff from Cache Creek, other than that from Clear Lake, would be regulated in Indian Valley Reservoir on the North Fork of Cache Creek and Wilson Valley Reservoir on the main stream, utilizing capacities of 250,000 and 210,000 acre-feet, respectively. These reservoirs would be operated for flood control, but their primary use would be to develop water for irrigation. The water would be used principally in Yolo County on lands west of Woodland. Development of Kelsey Creek was also proposed, as was the Yolo-Zamora Canal which is presently undergoing a feasibility study.

Scope of Current Planning Studies

The principal area of study during the current investigation centered around further investigation of the Wilson Valley

Project, which would develop sufficient water supplies on a firm basis to meet the needs for supplemental water in the Clear Lake-Cache Creek Basin for a number of years in the future. The Wilson Valley Project was analyzed with respect to its cost and accomplishments, economic justification, and financial feasibility as a project to be undertaken by local agencies. As discussed and described in detail in a later section of this chapter, the Wilson Valley Project consists of Wilson Valley and Brooks Reservoirs on Cache Creek, existing and improved diversion and distribution facilities of the Clear Lake Water Company, enlargement of the capacity of the Clear Lake outlet channel, and the coordinated operation of Clear Lake and Wilson Valley and Brooks Reservoirs to enhance the economy of the basin by provision of water conservation, flood control, and recreation benefits.

Consideration was also given to an alternative plan for providing supplemental water to the Cache Creek Service Area. This alternative, designated the "Alternative Cache Creek-Sacramento River Diversion Project", would consist of the Indian Valley Reservoir on the North Fork of Cache Creek, Brooks Reservoir on Cache Creek, the existing system of the Clear Lake Water Company, with improvements, and a system for importing water from the Sacramento River. This project was studied for purposes of comparison with the Wilson Valley Project, to ensure that the recommended plan would be the most economical plan for basin development.

As an alternative to a comprehensive plan for water development, studies were made of a single-purpose plan for providing flood control to the lands around Clear Lake. This plan would involve enlargement of the discharge capacity of the Clear

Lake outlet channel, in order to provide closer control of the water levels in Clear Lake by releasing additional water during times when the lake stage would exceed 7.5 feet on the Rumsey Gage. This project could also provide flood control benefits along Cache Creek by the additional control of releases from Clear Lake during times when tributaries to Cache Creek would be at peak flood stage.

With respect to water service in the Clear Lake Basin, the Kelseyville, Lakeport, and Pitney Ridge Projects, proposed in Bulletin No. 14, were reanalyzed in terms of conservation accomplishments. In addition, a plan for pumping supplemental water from Clear Lake was studied on a reconnaissance basis. This plan consisted of diversion, conveyance, and distribution systems which would serve Clear Lake water to lands in Big and Scott Valleys.

Project Water Requirements

Formulation of the plans for development described in this chapter had to be based upon definite data with respect to the water requirements which must be met. As evaluated and discussed in Chapter III, there is presently a need for supplemental water in the Cache Creek Service Area, and a substantial future need for supplemental water in both the Clear Lake Basin and the Cache Creek Service Area. This section discusses the relationship between the potential ultimate water requirements within the Clear Lake-Cache Creek Basin and those requirements which could reasonably be met by an initial plan for water development.

As shown in Chapter III (Table 29), the potential ultimate requirements for developed water in the Clear Lake Basin will be about 165,000 acre-feet per year on a gross application or delivery basis. About 38,000 acre-feet per year will be required in Big Valley, Scott Valley, and the Upper Lake area, as defined in Bulletin No. 14. The remainder, amounting to about 127,000 acre-feet per year, represents the requirements of service areas throughout the remainder of the basin. The majority of these service areas are scattered, lie at a considerable distance from Clear Lake, and are at higher elevations, all of which factors render plans for their water development rather impractical at this time. However, there are several communities adjacent to Clear Lake which must be considered in any plan to develop additional water within the Clear Lake Basin. These include the City of Lakeport and the communities of Nice, Clearlake Oaks, Clearlake Highlands, and other adjacent urban areas around the lake.

In studies to determine the yield of the Wilson Valley Project, which involved the coordinated operation of Clear Lake, Wilson Valley Reservoir, and Brooks Reservoir, it was necessary to allocate water supplies to upstream and downstream service areas. In consideration of the development potential in the Clear Lake Basin, it was assumed an annual amount of 36,000 acre-feet of water would be available for development, on the basis of gross application (net farm delivery) for Big Valley, Scott Valley, and the Upper Lake area, and 10,000 acre-feet for the remaining areas of imminent future needs. Considering the availability of an additional 9,000 acre-feet per year in Big Valley by replacing

present uneconomical use of ground water in swamp areas by irrigation development, this total of 45,000 acre-feet per year could be developed with a net depletion of inflow to Clear Lake of 21,000 acre-feet per year, as shown in the following tabulation:

	Gross application (net farm delivery), in acre-feet	Consumptive use of applied water (net depletion of inflow to Clear Lake), in acre-feet
Salvage of ground water by change in land use (Bulletin No. 14)	9,000	0
Increased ground water yield (Bulletin No. 14)	14,000	8,000
Surface storage and/or diversion from Clear Lake	<u>22,000</u>	<u>13,000</u>
Totals	45,000	21,000

The foregoing tabulation should be explained further. The first item of 9,000 acre-feet represents nonbeneficial consumptive use of ground water by native vegetation in high water table areas. By either bringing this land under irrigation or by lowering the water table by additional pumping, this ground water could be salvaged and put to beneficial use without depletion of the water supply available to Clear Lake. Increased ground water yield and surface water storage or diversion (the second and third items) could develop 36,000 acre-feet on a net delivery basis with a net depletion of inflow to Clear Lake of only 21,000 acre-feet. In this regard, it should be pointed out that the additional ground water yield could be obtained under present water rights within the basin.

With regard to the Cache Creek Service Area, most of the irrigable lands are within or adjacent to the distribution

facilities of the Clear Lake Water Company. Because all lands in the service area are susceptible of service with a nominal extension and improvement of the existing distribution system, it was considered that plans for water development would be based on meeting the full ultimate (2015) supplemental water requirement in the service area. The Wilson Valley Project and alternatives were formulated on this basis.

As discussed in Chapter III, the potential ultimate annual supplemental water requirement within the Cache Creek Service Area represents the difference between the safe yield of presently developed water supplies (232,000 acre-feet) and the potential ultimate (2015) water requirements (395,000 acre-feet), or 163,000 acre-feet, on the basis of gross application or farm head gate delivery. This supplemental water will be made available by increased delivery of firm surface supplies and by additional ground water recharge incidental thereto. Evaluation of the incremental surface and ground water supplies to be developed by proposed projects will be presented later in this chapter.

Economics of Water Development

Favorable climate, productive soils, the proximity of two large and growing metropolitan areas, and a large localized food processing industry all contribute to a prosperous agricultural economy and a favorable market situation for the Clear Lake-Cache Creek Basin. The Sacramento Metropolitan Area is within a half-hour drive of the Cache Creek Service Area, while the expansive San Francisco Bay Region is less than 100 miles away. Development of the Sacramento-Yolo Port District facilities

Harvesting sugar beets
in Yolo County



Superior Photo Service,
Woodland, photograph



Sugar beet refinery
near Woodland

Woodland Chamber of
Commerce photograph

and anticipated early completion of the Sacramento-Yolo Deep Water Channel should further enhance the opportunity for marketing bulk shipments of agricultural products grown in the basin.

The natural availability of ground water supplies has enabled the agricultural economy of the Clear Lake-Cache Creek Basin to develop to a considerable extent. With respect to the Cache Creek Service Area, the operation of surface water storage facilities and an extensive water distribution system has permitted the development of that area to a point where additional water can readily be absorbed with a minimum modification of existing facilities.

This section discusses the economic aspects of the provision of supplemental water supplies, without respect to a specific project. It presents data on the past and projected future yields, unit prices, and gross income for the principal crops grown in the basin; the estimated annual returns to land and water per acre under present water supply conditions; and payment capacities for the principal irrigated crops. The term "returns to land and water" refers to annual gross farm income minus all on-farm production costs, exclusive of interest cost on the capital value of land, and the cost of water. As a final step, the returns per acre are multiplied by the projected crop pattern to derive the total returns without additional water supply development. These data provide a base with which specific project proposals are compared in the evaluation of project benefits.

Crop Yields and Prices. Crop yields and prices adopted for evaluation of agricultural economics were based primarily on

averages for Yolo County as shown in the agricultural commissioner's reports. Additional sources, such as reports of the California Crop and Livestock Reporting Service, were utilized in making the projections of prices and yields.

The projected yields and prices were based on the historical average during the 5-year period from 1952 through 1956. The use of this base period has been adopted as a standard department procedure in agricultural studies as representative of the price-cost relationship that is expected to prevail during the project repayment period. In unusual cases, where the historical average was substantially affected by abnormal years, adjustments were made accordingly. The projected prices represent the gross income received by the producer at the first point of delivery. A compilation of historical and projected yields, prices, and gross income for selected crops within the Clear Lake-Cache Creek Basin is presented in Table 30.

Irrigation Benefits. The term "irrigation benefits" refers only to direct benefits, and is defined as the net increase in returns to land and water attributable to additional irrigation supplies. The computation of returns to land and water involved determination of gross income under fully irrigated conditions, as presented in Table 30, minus the sum of all production costs except interest on land and the cost of water. Returns to land and water under nonproject conditions were subtracted from the returns under project conditions, and the resultant figures comprised the irrigation benefits. The estimated annual irrigation benefits, over and above nonirrigated (dry-land) conditions, for selected irrigated crops in the Clear Lake-Cache Creek Basin are shown in Table 31.

HISTORICAL AND PROJECTED YIELDS, PRICES, AND GROSS INCOME FOR SELECTED CROPS AND LIVESTOCK IN CLEAR LAKE-CACHE CREEK BASIN

1/ Yields represent averages based on Agricultural Commissioner's Reports for Yolo County except for pears and apricots. The source for the latter is the California Crop and Livestock Reporting Service Reports.

Payment Capacity. The term "payment capacity" refers to the maximum amount of money the farmer can pay for water for the particular crop being considered. Payment capacity was derived as the difference between gross crop income and the total cost of production, excluding water. Inasmuch as the cost of production included management costs and interest on investment (land and equipment), the payment capacity represented a residual, or the amount of money which could be spent on the remaining factor of production -- water. Estimated annual payment capacity for selected irrigated crops in the Clear Lake-Cache Creek Basin is presented in Table 32.

TABLE 31

ESTIMATED ANNUAL IRRIGATION BENEFITS
FOR SELECTED IRRIGATED CROPS
IN CLEAR LAKE-CACHE CREEK BASIN

(In dollars per acre)

Irrigated	Gross: farm income	Cash overhead	Production costs to be deducted				Returns: to land and water	Dry land earnings	Irrigation benefits per acre
			Interest: and 1/ depreci- ation	Management charge	Variable	Total			
<u>Field</u>									
Alfalfa hay	144.00	10.35	22.75	14.00	55.90	103.00	41.00	15.00	26.00
Pasture	110.00	10.20	20.30	11.00	36.90	78.40	31.60	15.00	16.60
Sugar beets	260.00	17.20	26.80	26.00	133.00	203.00	57.00	15.00	42.00
Rice	158.00	11.00	21.00	16.00	73.00	121.00	37.00	15.00	22.00
<u>Truck</u>									
Tomatoes	405.00	26.00	41.00	40.00	229.00	336.00	69.00	15.00	54.00
<u>Orchards</u>									
Almonds	405.00	23.50	72.50	41.00	172.00	309.00	96.00	15.00	81.00
Prunes	500.00	30.00	70.00	50.00	267.00	417.00	83.00	15.00	68.00
Apricots	515.00	31.00	60.00	51.00	282.00	424.00	91.00	15.00	76.00
Walnuts	384.00	20.50	117.50	38.00	120.00	296.00	88.00	15.00	73.00
Pears	574.00	32.50	106.50	56.00	284.00	479.00	95.00	15.00	80.00

1/ Does not include interest return on land
(five percent of land value).

TABLE 32

ESTIMATED ANNUAL PAYMENT CAPACITY
FOR SELECTED IRRIGATED CROPS
IN CLEAR LAKE-CACHE CREEK BASIN

(In dollars per acre)

Crop	Cost of production, excluding water					: Payment
	: Gross :	Cash :	Interest and : Management :	Variable :	: Total :	
	: Income:	overhead :	depreciation :	charge :	cost :	: capacity
<u>Field</u>						
Alfalfa hay	144.00	10.35	42.75	14.00	55.90	123.00 21.00
Pasture	110.00	10.20	35.30	11.00	36.90	93.40 16.60
Sugar beets	260.00	17.20	56.80	26.00	133.00	233.00 27.00
Rice	158.00	11.00	36.00	16.00	73.00	136.00 22.00
<u>Grain</u>						
Barley	75.00	6.50	23.00	7.50	32.00	69.00 6.00
<u>Truck</u>						
Tomatoes	405.00	26.00	76.00	40.00	229.00	371.00 34.00
<u>Orchard</u>						
Almonds	405.00	23.50	112.50	41.00	172.00	349.00 56.00
Prunes	500.00	30.00	110.00	50.00	267.00	457.00 43.00
Apricots	515.00	31.00	100.00	51.00	282.00	464.00 51.00
Walnuts	384.00	20.50	157.00	38.00	120.00	336.00 48.00
Pears	574.00	32.50	146.50	36.00	284.00	519.00 55.00

Economics of Present Water Use in Cache Creek Service

Area. As previously stated, the safe annual yield of presently developed water supplies in the Cache Creek Service Area amounts to 232,000 acre-feet, consisting of 72,000 acre-feet from surface supplies and 160,000 acre-feet from ground water. Both urban and agricultural water is presently and will continue in the future to be drawn from the common ground water basin. Therefore, future agricultural water requirements must be analyzed in the light of an increasing urban water demand, as the pattern of urban use will affect the agricultural supply. It was assumed that the present water supplies (232,000 acre-feet per year) will be fully utilized, and that additional urban expansion will occur by encroachment upon agricultural areas. Under this assumption, the total area of water service would remain essentially constant, with the increase in urban area being offset by a corresponding decrease in the acreage of irrigated lands.

Projected future land use and water requirements in the Cache Creek Service Area under present water supply development are shown by decades in Table 33. The average agricultural returns (to land and water) in the Cache Creek Service Area, under present water supply development, are set forth, by decades, in Table 34. The values shown in Table 34 represent the products of the crop acreages from Table 33 and the returns to land and water from Table 31.

TABLE 33

PROJECTED LAND USE AND WATER REQUIREMENTS, BY
DECADES, IN CACHE CREEK SERVICE AREA UNDER
PRESENT WATER SUPPLY DEVELOPMENT

Land use	Average for decade					
	1965-74	1975-84	1985-94	1995-2004	2005-14	
	: Water	: Water	: Water	: Water	: Water	: Water
	: requirement,	: requirement,	: requirement,	: requirement,	: requirement,	: requirement,
	: Acreage : in acre-feet	: Acreage : in acre-feet	: Acreage : in acre-feet	: Acreage : in acre-feet	: Acreage : in acre-feet	: Acreage : in acre-feet
<u>Irrigated crops</u>						
Major irrigation						
season						
Orchard	9,450	24,600	9,260	24,100	8,980	23,300
Alfalfa	23,100	90,100	22,630	88,300	21,940	85,600
Pasture	11,340	48,700	11,110	47,800	10,770	46,300
Truck	9,950	26,900	9,750	26,300	9,450	25,500
Field	9,760	24,400	9,570	23,900	9,270	23,200
Subtotals	63,600	214,700	62,320	210,400	60,410	203,900
Minor irrigation						
season 1/						
Truck	3,670	5,500	3,600	5,400	3,490	5,200
Field	1,990	2,600	1,950	2,500	1,890	2,500
Totals	63,600	222,800	62,230	218,300	60,410	211,600
Urban	3,540	9,200	5,230	13,700	7,640	20,400
Totals	67,140	232,000	67,460	232,000	68,050	232,000

1/ Minor irrigation season represents double cropping. Therefore, acreage is not included in totals.

TABLE 34

AVERAGE ANNUAL AGRICULTURAL RETURNS
IN CACHE CREEK SERVICE AREA
UNDER PRESENT WATER SUPPLY DEVELOPMENT

		1965-74			1975-84			1985-94			1995-04			2005-14		
		Average : Returns to land and water, per acre : (in dollars)	Average : acreage : during : decade : (in acres):(in dollars):	Average : annual : returns, per decade : (in dollars):	Average : acreage : during : decade : (in acres):	Average : annual : returns, per decade : (in dollars):	Average : acreage : during : decade : (in acres):	Average : annual : returns, per decade : (in dollars):	Average : acreage : during : decade : (in acres):	Average : annual : returns, per decade : (in dollars):	Average : acreage : during : decade : (in acres):	Average : annual : returns, per decade : (in dollars):	Average : acreage : during : decade : (in acres):	Average : annual : returns, per decade : (in dollars):	Average : acreage : during : decade : (in acres):	
Irrigated lands																
Major season																
Alfalfa	41.00	23,100	947,100	22,630	927,800	21,940	899,500	21,030	862,200	19,960	818,400					
Pasture	31.60	11,340	358,300	11,110	351,100	10,770	340,300	10,320	326,100	9,800	309,900					
Field	57.00	9,760	556,300	9,570	545,500	9,270	528,400	8,890	506,700	8,440	481,100					
Truck	69.00	9,950	686,600	9,750	672,700	9,450	652,090	9,060	625,100	8,600	593,400					
Orchard	92.50	9,450	874,100	9,260	856,600	8,980	830,600	8,600	795,500	8,160	754,800					
Subtotals		63,600	3,422,400	62,320	3,353,700	60,410	3,250,900	57,900	3,115,600	54,960	2,957,600					
Minor season																
Truck	104.00	3,670	381,700	3,600	374,400	3,490	363,000	3,350	348,400	3,170	329,700					
Field	87.00	1,990	173,100	1,950	169,700	1,890	164,400	1,820	158,300	1,720	149,600					
Dry farmed	15.00	58,060	870,900	58,060	870,900	58,060	870,900	58,060	870,900	58,060	870,900					
Total agri- cultural returns			4,848,100		4,768,700		4,649,200		4,493,200		4,307,800					

The urban benefits in the Cache Creek Service Area under present water supply development are set forth, by decades, in Table 35. It will be noted in Table 35 that a value of \$34 was adopted as the benefit per acre-foot. This value was determined on the assumption that benefits accruing to an urban water supply would be at least as great as the benefits accruing to the alternative use for the highest value agricultural crops. The average annual return for orchard crops was evaluated at \$93 per acre. This figure was divided by the unit water requirement per acre (2.7 feet) for urban lands to obtain the adopted value of \$34.

The projected future urban water use under present water supply development was based on the urban acreages shown in Table 33. It is assumed that water to meet the urban use shown in Table 35 would be pumped from underlying ground water storage, and that the increase would be met by encroachment upon supplies currently used upon agricultural lands. It was assumed that the balance of the total future urban water requirements would be furnished by project water.

TABLE 35

AVERAGE ANNUAL URBAN WATER BENEFITS
IN CACHE CREEK SERVICE AREA
UNDER PRESENT WATER SUPPLY DEVELOPMENT

Decade	Urban water available under present water supply development (in acre-feet)	Return, per acre-foot (in dollars)	Average annual benefits per decade under present water supply development (in dollars)
1965-74	9,200	34	313,000
1975-84	13,700	34	466,000
1985-94	20,400	34	694,000
1995-04	29,200	34	993,000
2005-14	39,500	34	<u>1,343,000</u>
Total			3,809,000

Plans for Development in Clear Lake Basin

As stated earlier in this chapter, possible plans for development of the water resources of the Clear Lake Basin have been published in Bulletin No. 14. In brief review, Bulletin No. 14 proposed the Big Valley Project, consisting of Kelseyville Dam and Reservoir on Kelsey Creek, which would serve lands in Big Valley; the Lakeport Project, consisting of a dam and reservoir on Scott Creek, which would serve Scott Valley, Bachelor Valley, and the Helms, Tule, and Edmands Reclamation Districts; and the Pitney Ridge Project, consisting of a dam and reservoir on Middle Creek, which would serve lands in the Upper Lake area. These three reservoirs, with an aggregate storage capacity of 54,000 acre-feet, would develop a firm annual yield of 35,500

acre-feet, including 13,000 acre-feet of additional ground water yield. In addition, The California Water Plan proposed a fourth project consisting of Excelsior Dam and Reservoir on Copsey Creek. The storage capacity, firm annual yield, capital costs, and estimated annual costs per acre-foot of new yield, as published in Bulletins No. 3 and No. 14, are presented in the following tabulation:

	Storage capacity, in acre-feet	Yield, in acre-feet	Capital cost	Annual cost per acre-foot
Kelseyville	36,000	17,000 ^{1/}	\$2,421,000	\$ 7.90
Lakeport	12,800	9,300 ^{1/}	\$2,146,000	\$13.00
Pitney Ridge	5,400	8,200 ^{1/}	\$ 839,000	\$ 9.50
Excelsior	38,000	9,800	\$ 957,000	\$ 5.20

^{1/} Includes ground water yield of 13,000 acre-feet.

In this connection, Lake County and Yolo County entered into an agreement on May 17, 1960, whereby the two counties mutually agreed to respect each other's proposals for future water development, with particular reference to applications filed by Yolo County for the appropriation of unappropriated water of the Cache Creek watershed. In this agreement, a copy of which is included in Appendix A, Lake County specified the four reservoirs named in the foregoing paragraph, plus 5,000 acre-feet of storage in small reservoirs to be covered under future applications, which are not to be protested by Yolo County in connection with the applications on Cache Creek, filed by the latter county.

With regard to the proposals for further development of the water resources of the Clear Lake Basin proposed in Bulletin No. 14 and in Bulletin No. 3, and specified in the cited agreement between Lake and Yolo Counties, it should be emphasized that under the existing water rights permit of the Clear Lake Water Company, surplus surface waters of the Clear Lake Basin are limited to the present spills from Clear Lake. In other words, the storable inflows, or the amount of water which could be conserved in any surface storage development within the basin, are limited essentially to the flood flows which waste from Clear Lake during wetter years. During a drought period, such as that which occurred from 1928 through 1935, there would be practically no spills of surplus water from Clear Lake.

During the current investigation, monthly operation studies of Kelseyville, Lakeport, and Pitney Ridge Reservoirs were conducted for the 16-year period from 1920-21 through 1935-36. As the results of all three studies were similar, only the Kelseyville Reservoir operation study is described herein. In this study, Kelseyville Reservoir, with a storage capacity of 36,000 acre-feet, was operated on a new yield basis. Satisfaction of present established water rights would necessitate reservoir releases to meet existing downstream demands for ground water recharge in Big Valley, and preclude the storage of inflow when the Clear Lake stage was below elevation 7.56 on the Rumsey Gage. However, water stored in the reservoir during previous years would not have to be released for maintenance of the lake level.

It was found that during the 16-year period (1920-21 through 1935-36), Kelseyville Reservoir would have spilled only four times. However, during two of those years, stored water would have had to be released to Clear Lake under the limitations imposed by recognition of present downstream water rights. Moreover, Kelseyville Reservoir would have contained stored water during the entire year in only 7 of the 16 years of the operation period. Most significantly, however, for a 16-month period, such as existed from June of 1930 through September of 1931, the reservoir would have been completely empty. It was therefore concluded that an additional firm water supply could not be developed in Kelseyville Reservoir under existing water rights limitations imposed by users in the Cache Creek Basin. The same situation was found to prevail with respect to Lakeport and Pitney Ridge Reservoirs.

The foregoing analysis of the new yield of Kelseyville Reservoir serves to demonstrate conclusively that Lake County cannot develop additional surface water supplies within the Clear Lake Basin under present water rights held by downstream users. The only practicable means of enabling the further development of surface water supplies in the basin would involve either the joint participation by upstream and downstream users in a major water development project, wherein Clear Lake would be operated coordinately with storage on Cache Creek, or the purchase of water in Clear Lake if present conditions with respect to downstream water rights should prevail. Water made available by either method could be developed in upstream reservoirs or by diversion from Clear Lake.

Alternative Clear Lake Diversion Project

During the current investigation, a reconnaissance study was made of a possible plan involving the pumping of water from Clear Lake to meet future requirements for irrigation in Big Valley and Scott Valley. This plan was envisioned as an alternative to the development of Kelsey Creek and Scott Creek. The plan involved the diversion and delivery of water to the several service areas, but did not include distribution to the farms. Distribution could be accomplished either by surface facilities or by increased utilization of ground water storage. In this connection, the delivery points or canal terminuses were located near stream channels where ground water replenishment could be accomplished, thereby serving as a possible distribution facility.

Preliminary designs and cost estimates were made of the pumping plants, pipelines, and canals needed to divert water from the lake and convey it to the points of distribution. Estimates were based upon water requirements reported in Bulletin No. 14, topographic information from U. S. Geological Survey quadrangles, and preliminary cost estimating procedures. It was determined that the average annual cost of delivering about 29,000 acre-feet to Big Valley would be about \$11 per acre-foot. The average annual cost to deliver about 3,200 acre-feet to Scott Valley would be about \$5 per acre-foot. Plans for delivering supplemental water to the Upper Lake area were not included in this study because of the excessive cost for pumping and conveying water to the somewhat scattered irrigable land.

Location of the Alternative Clear Lake Diversion Project is shown on Plate 12, entitled "Existing and Alternative Water Supply Developments".

Wilson Valley Project

Additional water supplies sufficient to meet water requirements within the Clear Lake-Cache Creek Basin for a number of years into the future could be provided by construction of the Wilson Valley Project. The Wilson Valley Project would consist of a major dam and reservoir on Cache Creek at the Wilson Valley site, a small regulatory reservoir at the downstream Brooks site, and existing and improved facilities of the Clear Lake Water Company, which would be acquired and operated as part of the project. These latter works would include existing storage facilities in Clear Lake, an enlargement of the outlet channel capacity of Clear Lake, the existing distribution system of the company, and improvements to the distribution system. Location of the Wilson Valley Project is shown on Plate 12.

The Wilson Valley Project would provide a firm water supply to the downstream Cache Creek Service Area in the estimated amount of about 177,000 acre-feet per year, based on net farm delivery, of which an average of about 85,000 acre-feet presently is being delivered on a nonfirm basis. In addition, percolation losses from the conveyance, distribution, and application of the 92,000 acre-feet annually of new surface supplies would increase the availability of ground water by 43,000 acre-feet per year. Considering both surface and ground water yields, the project would increase the firm annual net farm delivery to

the Cache Creek Service Area by 148,000 acre-feet, which would nearly meet the potential ultimate (2015) supplemental water requirement in that area. Furthermore, the project would make available in Clear Lake sufficient water to permit users in the Clear Lake Basin to develop an additional 36,000 acre-feet per year, on a net farm delivery basis. This could be accomplished by deliveries from Clear Lake, by upstream storage, or by both, with a net annual depletion of 21,000 acre-feet to the inflow to Wilson Valley Reservoir.

In addition to conservation of water, the Wilson Valley Project would provide flood control to lands and improvements adjacent to Clear Lake, and to lands along Cache Creek in the Capay and Sacramento Valleys. Furthermore, recreational enhancement of Clear Lake would be realized from stabilization of the water surface levels resulting from project operation. Moreover, new recreational opportunities would be provided at Wilson Valley and Brooks Reservoirs, and along Cache Creek downstream from Wilson Valley Reservoir.

General Project Features

Wilson Valley Reservoir would have a storage capacity of 1,000,000 acre-feet. It would be operated to regulate spills from Clear Lake as well as the presently unregulated flows of the North Fork of Cache Creek. The existing 314,000 acre-feet of useable storage capacity in Clear Lake would be included as part of the Wilson Valley Project. Under the proposed plan of operation, all irrigation releases from the project would be made from Wilson Valley Reservoir until the reservoir stage would reach the

the minimum pool, at which time releases would be initiated from Clear Lake. It would be necessary to make releases from Clear Lake only during critical dry periods.

Water stored in Wilson Valley Reservoir would be released into the channel of Cache Creek to flow downstream for use in Capay Valley and for reregulation in Brooks Reservoir. Brooks Reservoir, which would have a storage capacity of 6,000 acre-feet, would provide daily and weekly peaking capacity to meet demands in the Cache Creek Service Area. The regulated supplies would be released into a distribution system for delivery throughout the Cache Creek Service Area. Brooks Reservoir also would be operated to provide partial regulation to the winter flows in Cache Creek, to enhance ground water recharge.

Flood control would be provided to lands along Cache Creek by the reservation of 65,000 acre-feet of flood storage space in Wilson Valley Reservoir. This space would be reserved during the period from November 1 to April 1, after which it would be utilized for conservation storage. Releases from Wilson Valley Reservoir during floods would be limited to flows of 15,000 second-feet at Rumsey, to prevent erosion along the lower Cache Creek channel. Flood protection to lands adjacent to Clear Lake would be achieved by enlarging the capacity of the Clear Lake outlet channel, from the present capacity of 2,500 second-feet to a capacity of 8,500 second-feet, at a lake stage of 7.56 feet on the Rumsey Gage at Lakeport. The flood flows passed from the lake would be regulated in Wilson Valley Reservoir.

Operation of the Wilson Valley Project would greatly enhance recreation around Clear Lake by stabilization of the lake.



Recreational opportunity at Wilson Valley and Brooks Reservoirs would also be provided by construction of on-shore recreation facilities. Moreover, stream flow releases from Wilson Valley Reservoir would enhance the sport fishery of Cache Creek.

Operation of the Wilson Valley Project would require a modification of existing court decrees which control the present operation of Clear Lake. As stated, the Wilson Valley Project would involve enlargement of the Clear Lake outlet channel, and closer control over lake levels by more rapid release of winter flood waters and by minimizing drawdown during the summer irrigation season. The Gopcevic Decree enjoins downstream users from deepening the Clear Lake outlet channel to any depth greater than 4 feet below the zero mark on the Rumsey Gage, and sets limits on the lowering of lake levels from irrigation releases for downstream use. The Bemmerly Decree superimposes a further limitation on the Gopcevic Decree, in that it precludes the widening or deepening, or enlarging in any manner, the Clear Lake outlet channel. Under project operation, there would be no need for these decrees as presently in force, as conditions which the decrees were designed to prevent would not exist. As stated in Chapter I, copies of the Gopcevic and Bemmerly Decrees are included in Appendix A.

Wilson Valley Dam and Reservoir. Wilson Valley Reservoir would be created by construction of a dam on the main stem of Cache Creek about 5 miles downstream from its confluence with the North Fork, or about 8 miles downstream from the crossing of the North Fork by State Highway Route 20. Several alternative dam sites were investigated in selecting the site for the Wilson

Valley Dam. The selected site, referred to as the lower Wilson Valley site, was chosen on the basis of foundation exploration, engineering design considerations, and economic analysis. This site is located in the southeast quarter of Section 19, Township 13 North, Range 5 West, Mount Diablo Base and Meridian. Stream bed elevation at the site is 867 feet above sea level, U. S. Geological Survey datum.

Wilson Valley is a reach of flat land extending along Cache Creek downstream from the mouth of Rocky Creek for a distance of about 2.5 miles. It is a remote area, accessible only by unimproved road which extends southward from the North Fork of Cache Creek crossing of California State Route 20. Wilson Valley, as well as the canyon of the North Fork of Cache Creek, would be completely inundated by a reservoir with a storage capacity of 1,000,000 acre-feet. Further, portions of California State Route 20 would require relocation.

Topographic maps of the Wilson Valley dam site and reservoir area at a scale of 1 inch equals 400 feet, with a contour interval of 20 feet, were prepared by the U. S. Bureau of Reclamation in 1946, using photogrammetric methods. Storage capacities and corresponding surface areas of Wilson Valley Reservoir at various stages of water surface elevation are shown in Table 36.

TABLE 36
AREAS AND STORAGE CAPACITIES OF
WILSON VALLEY RESERVOIR

Water surface elevation, in feet	Area, in acres	Storage capacity, in acre-feet
867	0	0
880	20	100
920	200	3,400
960	600	19,000
1,000	1,200	52,000
1,040	2,000	114,000
1,080	2,800	208,000
1,108	3,600	300,000
1,140	4,600	428,000
1,180	6,200	648,000
1,220	8,000	932,000
1,228	8,400	1,000,000

With the exception of the Wilson Valley Dam and Reservoir, all other features of the Wilson Valley Project would be common to any comprehensive plan for development of water resources of the Clear Lake-Cache Creek Basin. Specifically, those features considered essential to any alternative comprehensive plan would involve enlargement of the Clear Lake outlet channel, construction of downstream regulatory storage, and acquisition and enlargement of the existing diversion and distribution system of the Clear Lake Water Company. Therefore, selection of the size of the Wilson Valley Project was based upon consideration of

the relative costs and accomplishments of various sizes of dam and reservoir at the Wilson Valley site.

As a first step in determination of the size of the Wilson Valley Dam and Reservoir, estimates were made of the yield for various reservoir storage capacities, ranging from 300,000 acre-feet to 1,100,000 acre-feet. Preliminary estimates of cost were then prepared for each of these capacities. Finally, project accomplishments in terms of net annual benefits for each of the capacities were evaluated, and the size of dam and reservoir providing the greatest annual net benefits was selected.

Based on the foregoing considerations, a dam creating a reservoir with a storage capacity of 1,000,000 acre-feet was selected as the most favorable size of facility at the Wilson Valley site. Data on the capacity, yield at the dam site, and capital cost of the five reservoir capacities analyzed are shown in the following tabulation.

<u>Reservoir storage capacity (in acre-feet)</u>	<u>Annual yield at Capay Diversion (in acre-feet)</u>	<u>Estimated capital cost</u>
300,000	121,500	\$18,300,000
550,000	179,000	\$21,800,000
830,000	226,000	\$26,600,000
1,000,000	254,000	\$32,680,000
1,100,000	261,000	\$36,700,000

Based on findings of a geologic exploration program, the Wilson Valley Dam site is considered to be suitable for construction of a zoned earthfill or earth and rockfill dam of the heights considered. The supply of natural materials in and around Wilson

Valley is sufficient for construction of a large zoned fill dam.

Both abutments and the spillway site at the lower Wilson Valley Dam site are underlain by relatively impervious, interlayered beds of siltstone, shale, and sandstone of the Knoxville group, of probable lower Cretaceous age. These rocks dip steeply upstream. Even though the rocks are moderately fractured, only a moderate amount of grouting would be required below stripping depth. The stream channel is filled with gravel, sand, and some clay, to a maximum depth of 17 feet. Beneath the channel fill, the Knoxville rocks are fractured to a depth of about 30 feet. However, drill cores show that these rocks, when adequately grouted, will provide a good foundation capable of supporting an earth and rockfill dam. No evidence of major faulting is apparent in the drill cores.

In preparation of the foundation for the proposed dam the stream-channel deposits should be removed, and all of the weathered bedrock should be removed from beneath the impervious section in the channel. Approximately 10 feet of loose bedrock and soil should be stripped from the slope on the left abutment. The area beneath the impervious section would require additional stripping of 30 feet to expose suitable foundation material. On the right abutment approximately 5 feet of soil should be removed from the entire abutment area. Weathered and broken bedrock should be stripped to an additional depth of 20 feet beneath the impervious core area. Only the excavation for shaping would be required under the pervious fill. A grout curtain beneath the impervious core should be provided to assure a reasonable degree of cutoff of seepage beneath the dam.

The entire spillway area on the left abutment is underlain by interlayered beds of shale, siltstone, and sandstone of the Knoxville group. An extensive trenching exploration was conducted to determine foundation conditions in the spillway area. Results of laboratory tests indicated that a large percentage of the material excavated for the spillway would be suitable for use in construction of the dam. The spillway could be located either through the saddle northeast of the left abutment, or across the left abutment as presently proposed. Benching of the cut slopes at regular vertical intervals would permit stabilization of the foundation material at a 1 to 1 slope, thus minimizing the total volume of required excavation. Prevention of erosion and undercutting of the foundation material would necessitate lining of the entire spillway and construction of a suitable cutoff at the end of the lined section.

Although no earthquake epicenters have been recorded in the immediate vicinity of the dam site, it is prudent to assume that this area could be subjected to earthquakes of considerable intensity. Landslides constitute another hazard in the Cache Creek Canyon. Although the dam itself would not be endangered from landslides, the outlet works could be temporarily submerged as a result of downstream landslides which might block the creek channel. A dam at this site, however, could mitigate downstream danger from landslide activity by holding back the flow of the river until after the slide material could be removed from the stream.

Results of field investigation of potential construction materials indicated that requirements for impervious and pervious

fill and for aggregate could be met within a reasonable haul distance of the dam site. Ample quantities of acceptable fill materials could be obtained within a maximum distance of 11 miles upstream from the site along Cache Creek and North Fork Cache Creek. Gravel and sand for aggregate are available in this same general area, but these must be sampled and tested more extensively to determine suitability for concrete aggregate. Rip-rap may be obtained from outcrops of unweathered peridotite along Rocky Creek, approximately 1.5 miles west of the dam site. A detailed discussion of geologic conditions of the Wilson Valley Dam site and the location of possible construction materials is on file with the Department of Water Resources.

The selected dam, which would create reservoir storage capacity of 1,000,000 acre-feet, would have a height of 377 feet above stream bed, a crest length of 1,340 feet, a crest width of 30 feet, and upstream and downstream slopes of 3 to 1 and 2.25 to 1, respectively. The central impervious core of the dam would be constructed of compacted earth, and would have a top width of 10 feet and side slopes of 0.5 to 1. The outer pervious zone of the dam would consist of free draining stream bed gravels, obtained from alluvium and terrace deposits which extend for several miles in the upstream and downstream channel. The total volume of fill would be about 8,600,000 cubic yards, including 2,000,000 cubic yards in the impervious zone.

An ungated side channel spillway would be located on the steep slope of the left abutment. This spillway would be concrete lined, and would consist of an approach channel, an ogee weir overflow structure, and a chute terminating in a flip bucket which would impart an upward thrust to the discharge, thus minimizing channel scour. The spillway was designed to pass a discharge of 45,000 second-feet with a maximum depth of 10 feet above the spillway lip, with an additional 6 feet of freeboard. The spillway was sized on the premise that the design flood would occur with a completely filled reservoir, including the 65,000 acre-feet of flood control storage. The project-design flood was determined from a standard flood frequency analysis based on recorded runoff in Cache Creek.

The reservoir would be operated to provide a flood control storage reservation of 65,000 acre-feet during the winter months, to control downstream flood control releases to 15,000 second-feet whenever possible, and to utilize the flood control storage for conservation during later spring months after the threat of floods has passed. This conservation would be accomplished by means of a 30-foot by 40-foot radial gate located in the approach channel to the spillway below the overpour section. With the radial gate in a closed position the reservoir could fill to the spillway lip. However, with the gate in an open position, 65,000 acre-feet of flood control storage would be reserved, and releases would be controlled to approximately 15,000 second-feet to avoid excessive erosion in the downstream channel. The operation of the radial gate, and its relationship with respect to the reservoir and spillway structure, can be seen by reference to Plate 13, entitled "Wilson Valley Dam on Cache Creek".

During construction of the dam, Cache Creek would be diverted through a 28-foot diameter tunnel, about 1,680 feet in length, constructed through the right abutment. After completion of the dam, the tunnel would become part of the outlet works. The tunnel inlet would consist of a transition structure covered by a sloping trashrack. Two 72-inch diameter steel pipes would be installed, extending from the outlet structure to a gate chamber in the diversion tunnel just upstream from the axis of the dam. Upon completion of the dam, the diversion tunnel would be plugged immediately upstream from the gate chamber, which chamber would contain two 4-1/2- by 4-1/2-foot pressure slide gates for control of releases. The outlet structure would contain two 66-inch diameter Howell-Bunger type valves, which would control releases into a lined chute located near the downstream toe of the dam.

The area that would be inundated by Wilson Valley Reservoir is sparsely settled open range, presently utilized for livestock grazing. There are few residences within the area, and no significant areas of irrigated land. Commercial establishments include gravel pits along the North Fork of Cache Creek, a minnow raising operation in the same area, and the inoperative Myra sulfur mine near the high water line in Section 12, Township 14 North, Range 7 West. Approximately 10,200 acres of land would have to be acquired for the 1,000,000 acre-foot Wilson Valley Reservoir.

The estimate of cost of acquisition of the Wilson Valley Reservoir site was based upon preliminary estimates of the value of lands and improvements within the reservoir. Real estate was evaluated by the market analysis method, in which each tract

of land was appraised by comparison with recent transactions in which similar properties were involved. Data on land ownership and descriptions of properties were obtained from the Yolo County Assessor, and data on sales and costs of properties in and adjacent to the areas were obtained from the county recorder and from local real estate agencies. It was assumed that the market value of land and property would represent the present worth of the future productivity of lands flooded by reservoir development.

Estimates also were made of damages to property owners because of adverse effects of severance of property, reduction of area of operation, loss of or obstruction of communications, and other elements. All developed lands, as well as the accessible portions of the undeveloped lands within the reservoir areas, were inspected and evaluated in the field.

The State Division of Highways, in cooperation with the Department of Water Resources, made a preliminary study of alternative routes for relocating State Highway 20 around the proposed Wilson Valley Reservoir. Cost estimates were based upon improvement of the relocated route to expressway standards. The portion of cost for relocation in kind is included in the estimate of reservoir cost, and it was assumed that the State Highway Commission would contribute the portion of the cost required for improvement of the route.

Pertinent data with respect to general features of the Wilson Valley Dam and Reservoir, as designed for cost estimating purposes, are presented in Table 37.

TABLE 37
GENERAL FEATURES OF
WILSON VALLEY DAM AND RESERVOIR

<u>Dam</u>	
Type	earthfill
Crest elevation, in feet	1,244
Crest length, in feet	1,340
Crest width, in feet	30
Height above stream bed, in feet	377
Freeboard above maximum water surface, in feet	6
<u>Side slopes</u>	
Upstream	3:1
Downstream	2.25:1
Elevation of stream bed, in feet	867
Volume of fill, in cubic yards	8,600,000
<u>Reservoir</u>	
Surface area at spillway lip, in acres	8,400
Storage capacity at spillway lip, in acre-feet	1,000,000
Drainage area, in square miles	800
Average seasonal runoff, in acre-feet	372,000
Seasonal yield of water, in acre-feet	252,000
Type of spillway	lined side channel
Spillway discharge capacity, in second-feet	45,000
Type of conservation outlet works	Two 72-inch diameter steel pipes in tunnel through right abutment
Type of flood control outlet	30-foot by 40-foot radial gate in upstream end of spillway inlet structure

The capital cost of the Wilson Valley Dam and Reservoir is estimated to be \$34,515,000, based upon prices prevailing in the spring of 1960. The capital cost is broken down by principal features in the following tabulation, and is presented in detail in Appendix B.

Dam

Embankment	\$14,506,000
Spillway	\$ 4,486,000
Outlet works	\$ 4,418,000

Reservoir

Lands and improvements	\$ 2,484,000
Relocation of utilities	
State Highway 20	\$ 8,229,000
County roads	\$ 392,000

It may be noted that the cost of relocation of State Highway 20 amounts to \$8,229,000. This value includes, in addition to the cost of replacement at existing standards, the cost of improvement to expressway standards. The State Division of Highways has estimated that relocation of State Highway 20 around Wilson Valley Reservoir would cost \$6,348,000 for replacement at existing standards, and an additional \$1,735,000 for replacement to expressway standards.

Brooks Dam and Reservoir. Brooks Reservoir would be created by construction of a dam on Cache Creek in the northwest 1/4 of Section 7, Township 10 North, Range 2 West, Mount Diablo Base and Meridian about 3 miles upstream from the existing Capay Diversion Dam. The location of Brooks Dam is shown on Plate 12.

Brooks Dam would serve two principal purposes: (1) To provide forebay capacity for the downstream distribution system in the Cache Creek Service Area so that peak irrigation demands could be met without wide fluctuations in the flow of Cache Creek; and (2) To regulate flood runoff from the drainage area below

Wilson Valley Reservoir so that releases could be made to lower Cache Creek at rates that would percolate to ground water basins. Releases from Brooks Reservoir for percolation to maintain ground water levels could be made at amounts up to 300 second-feet without experiencing outflow at the Yolo Gaging Station. Records show that percolation rates of 300 second-feet could be maintained for at least one month, and that rates of 150 second-feet could be maintained for one month, and, subsequently, 150 second-feet could be maintained for four months.

A topographic map of the dam site and reservoir area, at a scale of one inch equals 2,000 feet, was prepared by U. S. Geological Survey in 1939 for a 29-mile reach of Cache Creek above Capay Diversion Dam. This map, with 10-foot contour interval, was considered adequate for preliminary planning. Storage capacities and corresponding surface areas of Brooks Reservoir at various stages of water surface elevation are shown in Table 38.

TABLE 38

AREAS AND CAPACITIES OF BROOKS RESERVOIR

Water surface elevation, : in feet, USGS datum	: Area, in acres	: Storage capacity, in acre-feet
240	0	0
250	50	180
260	100	890
270	210	2,400
280	560	6,200
290	1,060	14,300

Based upon the topography and the spillway flood requirements at the Brooks site, a gross reservoir storage capacity of 6,200 acre-feet was selected. At a normal pool elevation of 280 feet, U. S. Geological Survey datum, the water surface area would be 560 acres.

From a surficial field inspection and review of the available geology reports on Brooks Dam site, the site appears to be geologically suitable for construction of the proposed dam. The dam site consists of a 300-foot wide channel, with a steep right abutment and a gently sloping left abutment. The area is underlain by moderately hard, bedded sandstone and shale of the Chico formation of Cretaceous age, and by the moderately consolidated siltstone, mudstone, and sandstone of the Tehama formation of Pliocene age. Vertical joints are prominent in the harder rocks. A fault was noted behind the left abutment and small landslides were noted in both abutments, but these do not pose any major problem.

The channel of Cache Creek at the Brooks site is filled to an average depth of at least 25 feet with boulders, gravel, and sand. Exploration will be required to determine the maximum depth of this loose channel fill material. Foundation preparation for the dam should include removal of all of this loose channel material. The sand and gravel in Cache Creek will provide an ample source of aggregate for concrete, but these should be tested for reactivity and durability. Seismic activity in the region around the Brooks Dam site is considered to be moderate.

The dam, as designed for cost estimating purposes, would be of the concrete-gravity type, with a central overpour spillway.

It would be 60 feet in height from stream bed to spillway lip, with a crest elevation of 290 feet. The crest length would be 575 feet. The spillway, 425 feet in length, would be formed by the ogee section of the concrete gravity dam. The abutment sections would provide for 10 feet of surcharge above the spillway lip. The discharge capacity of the spillway, with 10 feet of surcharge, would be 47,300 second-feet. In selecting the spilling capacity, it was assumed that Brooks Reservoir would be constructed subsequent to Wilson Valley Reservoir. An efficient facility for energy dissipation would be required at the toe of the dam along the spillway section to prevent scouring. In this preliminary design it was considered that large, hard rock from excavation of the foundation would be placed as riprap. Additional studies might indicate that a stilling basin would be more desirable.

The outlet works would consist of a 6-foot diameter pipe installed through the dam. Releases of stored water for both irrigation and ground water recharge would be controlled by four slide gates.

Lands to be inundated by Brooks Reservoir are, for the most part, irrigable. Much of the land is presently dry farmed, and only limited areas are irrigated. The maximum water surface would be limited to an elevation of 290 feet to avoid flooding other irrigable areas above this level. The reservoir would lend itself to recreation use because of the small daily and weekly fluctuation during the summer irrigation season.

Pertinent data with respect to general features of Brooks Dam and Reservoir, as designed for cost estimating purposes,

are presented in Table 39. Principal features of the dam are shown on Plate 14, entitled "Brooks Dam on Cache Creek". The capital cost of Brooks Dam and Reservoir is estimated to be \$1,819,000, based upon prices prevailing in the spring of 1960. This cost estimate is presented in detail in Appendix B.

TABLE 39
GENERAL FEATURES OF BROOKS DAM AND RESERVOIR

<u>Dam</u>	
Type	concrete gravity
Crest elevation, in feet,	
USGS datum	290
Crest length, in feet	575
Height of spillway crest	
above stream bed, in feet	40
Freeboard, above spillway	
crest, in feet	10
Elevation of stream bed,	
in feet	240
Volume of concrete, in cubic yards	21,200
<u>Reservoir</u>	
Surface area at spillway	
lip, in acres	560
Storage capacity at spillway	
lip, in acre-feet	6,200
Drainage area, Wilson Valley Dam	
to Brooks Dam, in square miles	249
Average annual runoff from drainage	
area below Wilson Valley Dam,	
in acre-feet	64,000
Type of spillway	ungated overpour spillway on concrete gravity section
Spillway discharge capacity,	
in second-feet	47,300
Type of outlet works	6-foot diameter conduit with slide gates

Distribution System. The yield of the Wilson Valley Project made available for use in the Cache Creek Service Area would be released into Cache Creek on an irrigation-demand schedule, and reregulated in Brooks Reservoir to meet farm

irrigation demands. Releases from Brooks Reservoir for irrigation would be diverted into the existing distribution system at the Capay Diversion Dam.

Water service to the Cache Creek Service Area was considered individually for the Capay Valley, Hungry Hollow, Moore, and Winters Units. Water service to irrigated lands would largely utilize the canal systems already developed by the Clear Lake Water Company and its predecessors. Portions of the existing canals have sufficient capacity to meet future demands, while other portions would require enlargement. In some areas new canals and laterals would be constructed to provide irrigation water service. Estimated annual irrigation demands from surface and ground water for each of the units are shown in Table 40. Cost estimates of improvements to the distribution system were based on maximum irrigation requirements, which were forecast to occur in 1975.

TABLE 40

PROJECTED ANNUAL USE OF
GROUND WATER AND SURFACE
WATER IN CACHE CREEK
SERVICE AREA, IN 1975,
WITH WILSON VALLEY PROJECT

(In acre-feet)

Unit	: Total water : : requirement at : : farm head gate : : or equivalent : : (1975)	Source of		: Canal : : losses :	: Total surface : : water diversion : : requirement
		Ground water	Surface water		
Capay Valley	17,300	8,000	9,300	2,300	11,600
Hungry Hollow	33,400	11,000	22,400	5,600	28,000
Winters	222,000	92,000	130,000	32,600	162,600
Moore	<u>107,500</u>	<u>92,000</u>	<u>15,500</u>	<u>3,900</u>	<u>19,400</u>
Totals	380,000	203,000	177,200	44,400	221,600

The maximum (1975) irrigation water requirement within the Capay Valley Unit was estimated to be 17,300 acre-feet per year. Assuming that ground water draft would remain at the present rate of about 8,000 acre-feet per year, 9,300 acre-feet would be required for delivery at the farms from surface water sources. Including canal losses, 11,600 acre-feet of water per year would have to be diverted from project releases into Cache Creek.

Project water service to Capay Valley would be provided by an unlined canal with an initial discharge capacity of 50 second-feet. From the diversion point, upstream from Rumsey, this canal would extend about 11 miles along the west side of Capay Valley. Distribution would be made by turnouts from the main canal and by short laterals to the farms.

Because of the topography and the characteristics of the underlying ground water basin, all return flows from irrigation application in the Capay Valley Unit would drain to Cache Creek above Brooks Reservoir, and would be available for re-use in the remainder of the system. It was estimated that the capital cost of distribution facilities in Capay Valley would be about \$265,000.

The maximum (1975) water requirement in the Hungry Hollow Unit was estimated to be 33,400 acre-feet per year. With ground water draft remaining at the present rate of 11,000 acre-feet per year, 22,400 acre-feet of water would have to be delivered to the farm head gates from surface water sources. Including canal losses, 28,000 acre-feet per year would have to be diverted from project releases below Brooks Reservoir.

Capay Diversion Dam
showing West Adams
Canal intake at
north end of dam



Beginning of Winters
Canal showing diversion
structure at south end of
Capay Diversion Dam

The existing Hungry Hollow and West Adams Canals, with improvements and extensions, would serve the Hungry Hollow Unit. It was estimated that diversions under project conditions into the Hungry Hollow and West Adams Canals would be about 70 and 80 second-feet, respectively. Both of these canals presently have capacities in excess of these amounts. It was further estimated that the capital cost of improving, extending, and providing additional farm lateral systems would be about \$290,000.

The maximum (1975) water requirement within the Winters Unit was estimated to be 222,000 acre-feet per year under project conditions. It was assumed that ground water draft would remain at about the present rate of 92,000 acre-feet per year. Ground water would meet requirements for domestic and urban purposes, as well as for irrigation. By diverting about 163,000 acre-feet of water per year, including canal losses, from project releases below Brooks Reservoir, about 130,000 acre-feet per year would be delivered to farms.

The diversion and conveyance of water from Cache Creek for service to the Winters Unit would be accomplished by means of the existing Winters Canal, which diverts at Capay Dam. This canal would be enlarged from its present capacity of 470 second-feet to about 650 second-feet to properly meet project requirements. Portions of this canal are concrete lined, and would remain so under project conditions. Releases made from the Winters Canal to the Esparto area, and to the Cottonwood, Yolo Central, and Pleasant Prairie Canals, would reduce the Winters Canal capacity to about 130 second-feet. No enlargement would be needed beyond the Pleasant Prairie Canal turnout. It was estimated that the

capital cost of enlarging the 10-mile length of the Winters Canal from Cache Creek to the Pleasant Prairie Canal would be about \$945,000.

Records of the Clear Lake Water Company show that, at one time or another, nearly all the Winters Unit has been served by water from Cache Creek. A review of capacities of the six distribution canals fed by the Winters Canal shows that nearly all the canals have adequate capacity to deliver project water. The main exception is the Pleasant Prairie Canal, which would require enlargement from a capacity of 60 second-feet to 170 second-feet for a distance of 8 miles. Additional distribution laterals would have to be constructed to serve about 7,000 acres to the east of the present terminus of the Canal. Improvement and extension of laterals would have to be provided for about 15,000 acres served by the other canals. It was estimated that the capital cost for enlargement of the Pleasant Prairie Canal and improvement of distribution laterals in the Winters Unit would be about \$1,875,000.

The maximum (1975) water requirement in the Moore Unit was estimated to be 107,500 acre-feet per year. It was assumed that the amount pumped from ground water would remain at about the present rate of 92,000 acre-feet per year. The amount of water to be diverted from Cache Creek would be 19,400 acre-feet per year, including canal losses. Releases from Brooks Reservoir would be made using the existing system for conveying water from the Capay Diversion Dam to the Moore diversion through the West Adams Canal. The existing Moore Canal has adequate capacity to divert the maximum project flows of 75 second-feet. Also, the Moore Canal and its present laterals can provide water service

to most of the Moore Unit. It was estimated that the capital cost of improving and extending laterals for water service to 3,200 acres in the Moore Unit would be about \$207,000.

The total cost of improving and extending the distribution system, as described herein, was estimated to be \$3,582,000, including engineering, administration, contingencies, and interest during construction. This cost is summarized for the described features in the following tabulation:

Capay Valley Unit

Construction of Capay Valley Canal	\$ 265,000
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Hungry Hollow Unit

Extension of West Adams and Hungry Hollow Canals	\$ 290,000
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Winters Unit

Enlargement of Winters Canal	\$ 945,000
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Enlargement of Pleasant Prairie Canal	\$ 400,000
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Construction of distribution laterals for Winters and Pleasant Prairie Canals	\$1,475,000
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Moore Unit

Construction of distribution laterals under Winters Canal	\$ 207,000
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If staging of improvement of the distribution system were found to be desirable, the improvements needed first would be those to enlarge and extend laterals serving the Winters area. These features would cost \$1,875,000. Enlargement of a 10-mile length of the Winters Canal could be delayed for a later stage of development.

It should be noted that the foregoing cost estimate of \$3,582,000 covers only improvement and extension of the existing distribution system, and does not include the cost of acquisition of the system from the Clear Lake Water Company. Since the Wilson Valley Project includes the distribution system of that company, it was necessary to assume a cost of acquisition of the system, for purposes of economic analysis and allocation of costs, to be discussed and evaluated in a later section of this chapter. In this connection, determination of the sale value of a private utility is a matter to be settled by negotiation between the two parties concerned, and is beyond the purview of this department. In order to avoid the prejudice of either party to possible future negotiation, the book value of the distribution system of the Clear Lake Water Company, as published in the annual report of the Public Utilities Commission, was used in the current studies as the assumed cost of acquisition of the system. The book value, amounting to \$1,163,000 as of December 31, 1958, should not be taken in any manner as an implication of the sales value of the system.

Clear Lake Outlet Channel Enlargement. Enlargement of the Clear Lake outlet channel, as a feature of the Wilson Valley Project, would alleviate flooding of the Clear Lake shore line. As stated in Chapter III, lake levels have exceeded the flood stage of 9.0 feet on the Rumsey Gage near Lakeport 20 times since 1874. In February, March, and April of 1958, the lake reached a maximum elevation of 10.88 feet, and exceeded 9.0 feet for a total of 44 days.

Enlargement of the Clear Lake outlet channel has been proposed in past years by both state and federal agencies. The former Division of Water Resources recommended in its report, "Clear Lake-Cache Creek Flood Control Investigation", dated February, 1939, that the channel be enlarged to a discharge capacity of 8,500 second-feet. The U. S. Corps of Engineers considered enlargement of the channel to a capacity of 8,000 second-feet in its review report of July, 1950, on the Cache Creek Basin.

The Clear Lake outlet channel comprises the 5-mile reach from Clear Lake near Clearlake Highlands to the Clear Lake Impounding Dam. The location and features of the outlet channel are shown on Plate 15, entitled "Clear Lake Outlet Enlargement". In its western portion, the outlet channel flows placidly through a shallow marsh area and then enters the well-defined channel of Cache Creek. The channel passes over the Grigsby Riffle just upstream from Siegler Creek, and then flows with considerably more slope for about three more miles to the Clear Lake Impounding Dam. The Grigsby Riffle is an outcrop of hard material, chiefly well-cemented boulders, with a stream bottom elevation of about 4 feet below zero on the Rumsey Gage. This natural constriction in the channel, rather than the Clear Lake Impounding Dam, controls and limits the outflow from Clear Lake under flood conditions.

Stream flow measurements show that the discharge capacity of the Clear Lake outlet channel is about 2,500 second-feet with the lake at an elevation of 7.56 feet on the Rumsey Gage, as limited by the Grigsby Riffle. However, the discharge capacity of the Clear Lake Impounding Dam at the same elevation on the Rumsey

Gage has been computed to be about 15,000 second-feet with all gates open. The maximum discharge passing through the outlet channel during the flood of 1958, as limited by the Grigsby Riffle, was estimated to be about 5,000 second-feet.

An enlarged Clear Lake outlet channel with a discharge capacity of 8,500 second-feet at a reading of 7.56 feet on the Rumsey Gage was selected during the current investigation as the most feasible improvement. This capacity would have prevented the floods of February, 1956 and February, 1958 from reaching damaging levels, and would greatly reduce damages from the projected 1- in 100-year and 1- in 1,000-year floods.

A topographic map of the Clear Lake outlet channel and adjacent area was made by the Department of Water Resources in 1958, utilizing photogrammetric methods. The features of this map were supplemented by an underwater survey using a fathometer to determine the configuration of the channel bottom. The character of material to be excavated was determined by field inspection, and from information provided by the Clear Lake Water Company regarding previous excavations to increase the outlet channel capacity. These previous excavation attempts were halted by the Gopcevic and Bemmerly Decrees. It was assumed that these restrictions against deepening or widening the outlet channel would be removed under operation of the Wilson Valley Project.

The proposed plan and profile of the enlarged Clear Lake outlet channel, as designed for cost estimating purposes, is shown on Plate 15. This plate also shows typical cross sections of the enlarged channel.

It was estimated that the channel enlargement would require excavation of about 820,000 cubic yards of channel material. This would include about 240,000 cubic yards of rock and earth in the vicinity of the Grigsby Riffle and the Narrows, and about 580,000 cubic yards of mud, silt, and earth in the eastern and western reaches of the channel. Construction would also involve replacement of retaining walls along the Grigsby Riffle, and lowering of the footings of the Highway No. 53 bridge. It was estimated that the capital cost of enlarging the Clear Lake outlet channel would be about \$1,250,000.

Summary of Project Costs. The overall capital cost of the Wilson Valley Project, as described in the foregoing sections of this chapter, was estimated to be \$45,010,000. The corresponding annual cost of the project was estimated to be \$2,942,000, based upon a repayment period of 50 years at an interest rate of 4 percent, and including the annual costs of operation, maintenance, and replacement. A summary of the estimates of capital and annual costs of the several major facilities comprising the Wilson Valley Project is presented in Table 41. It may be noted that Table 41 includes an additional column showing the capital cost of the project including the present worth of the annual operation and maintenance costs over the 50-year repayment period. This latter value was used in the project cost allocation, which will be presented in a later section of this chapter.

SUMMARY OF ESTIMATED CAPITAL AND ANNUAL COSTS OF
WILSON VALLEY PROJECT BY MAJOR FEATURES

(In dollars)

Feature	:	:	:	Annual costs			Capital cost,		
				: Operation,	: maintenance,	: replacement,	: Capital	: recovery	: including present
				:	:	:	:	:	: worth of operation
				:	:	:	:	:	: and maintenance,
				:	:	:	:	:	: and replacement, and
				:	:	:	:	:	: general expense
				:	:	:	:	:	: over 50-year period
				:	:	:	:	:	:
Wilson Valley Dam and Reservoir		^{1/}		34,515,000	1,607,000	212,000	1,819,000		39,133,000
Clear Lake Outlet Enlargement				1,250,000	58,000	10,000	68,000		1,465,000
Brooks Dam and Reservoir				1,819,000	85,000	13,000	98,000		2,104,000
Distribution system:									
First stage		^{2/}		3,039,000	141,000	228,000	369,000		8,000,000
Final stage				1,707,000	79,000	81,000	160,000		2,353,000
Public recreation facilities:									
At Wilson Valley Reservoir				1,750,000	82,000	220,000	302,000		6,383,000
At Clear Lake				<u>930,000</u>	<u>43,000</u>	<u>83,000</u>	<u>126,000</u>		<u>2,426,000</u>
Totals				45,010,000	2,095,000	847,000	2,942,000		61,864,000

^{1/} Includes \$1,735,000 for improvement of relocated highway to expressway standards.

^{2/} Includes cost of Clear Lake Water Company as depreciated book value shown in annual report to Public Utilities Commission.

Project Accomplishments

The Wilson Valley Project would: (1) Provide water for irrigation, municipal, and industrial purposes, both in the Clear Lake Basin and in the Cache Creek Service Area; (2) Provide flood control to lands and improvements adjacent to Clear Lake and along Cache Creek downstream from the Wilson Valley Dam, and extend the period of use of the Cache Creek settling basin; and (3) Provide recreational enhancement around Clear Lake, and new recreational opportunity at Wilson Valley and Brooks Reservoirs and along Cache Creek downstream from the Wilson Valley Dam. This section describes physical accomplishments of the Wilson Valley Project and evaluates these accomplishments in terms of monetary benefits.

Conservation of Irrigation and Urban Water. As previously stated, the Wilson Valley Project would be operated in such manner as to make available 36,000 acre-feet of water per year in Clear Lake for use within the Clear Lake Basin, which use would deplete inflow to Wilson Valley Reservoir by 21,000 acre-feet per year. The project yield to be made available to the Cache Creek Service Area was determined as the difference between the total system yield, both surface and ground water, under project operation and the system yield under present water supply development. From a detailed monthly routing study for the project during the 45-year period from 1913-14 through 1957-58, it was determined that, in addition to the 36,000 acre-feet of annual yield made available in Clear Lake, a firm annual yield of 218,000 acre-feet could be obtained at the downstream Capay Diversion Dam. This value represents a gross diversion from Cache Creek, and includes conveyance

and distribution losses. An annual summary of the detailed routing study of the Wilson Valley Project for the 45-year period is included as Appendix C.

The estimates of yield of the Wilson Valley Project were based upon operation of 314,000 acre-feet of storage in Clear Lake, between minimum and maximum elevations of zero feet and 7.56 feet, respectively, on the Rumsey Gage; operation of Wilson Valley Reservoir, with a gross storage capacity of 1,000,000 acre-feet; and operation of 6,000 acre-feet of storage in the downstream Brooks regulatory reservoir. Of the storage capacity in Wilson Valley Reservoir, 885,000 acre-feet would be used for conservation, 65,000 acre-feet below the spillway lip would be reserved for flood control between December 1 and April 1, and 50,000 acre-feet of dead storage capacity would comprise a minimum recreational pool and be available for silt storage. The flood control storage reservation could be filled for conservation after April 1 by closing the radial gate in the spillway channel approach.

In addition to the firm annual yield of 218,000 acre-feet, to be available at the Capay Diversion Dam, an annual quantity of 15,000 acre-feet of water would be released from Wilson Valley Reservoir to the downstream Cache Creek channel for fisheries enhancement and for maintenance of present ground water replenishment from the creek. This downstream channel release would comply with terms of an agreement between Yolo County and the State Department of Fish and Game that a minimum flow of 10 second-feet be maintained between the Wilson Valley Project and the Capay Diversion Dam during winter months when no releases for

irrigation would be necessary. This agreement, which is included in Appendix A, was consummated by the two agencies to establish mutually satisfactory conditions in any permit granted by the State Water Rights Board to Yolo County for further development of Cache Creek.

With regard to the foregoing agreement, maintenance of present ground water replenishment from the Cache Creek channel would necessitate sufficient releases to ensure a minimum flow in Cache Creek of 50 second-feet during winter months. The releases would also satisfy the fisheries requirement. In addition, such a minimum flow would provide a substantial measure of recreation enhancement.

A typical schedule of monthly demands for releases from the Wilson Valley Project is presented in Table 42. It may be noted that the diversions shown in Table 42 are designated for irrigation purposes only. This situation would prevail during early years of project operation when agricultural uses would absorb the entire surface supply. Urban water requirements during the early years would be met by increased ground water draft. In this connection, it is anticipated that irrigation deliveries from the project would reach a peak in 1975, and decline slightly thereafter as urban development encroaches upon agricultural lands.

Of the estimated firm annual yield of 218,000 acre-feet which would be made available for diversion at the Capay Diversion Dam, about 177,000 acre-feet per year would be delivered to farms. Distribution throughout the Cache Creek Service Area would be accomplished by extending and enlarging certain features of the existing distribution system of the Clear Lake Water Company.

PROPOSED SCHEDULE OF MONTHLY DEMANDS
FOR WATER FROM WILSON VALLEY PROJECT

(In acre-feet)

Month	Water	Project	Releases for	Diversions for Irrigation			
	available	water	stream flow	in Cache Creek Service Area			
	in Clear	at Capay	maintenance	Major	Minor		
	Lake, for	use in	and ground	irrigation	irrigation	season	Totals
	Clear Lake	Diversion	water recharge	season	season		
	Basin	Dam					
October	800	4,400	0	2,500	1,900		4,400
November	200	4,900	3,000	0	1,900		1,900
December	0	3,000	3,000	0	0		0
January	0	3,000	3,000	0	0		0
February	0	3,000	3,000	0	0		0
March	0	4,400	3,000	0	1,400		1,400
April	400	9,700	0	8,200	1,500		9,700
May	2,100	40,200	0	40,200	0		40,200
June	4,500	45,600	0	45,600	0		45,600
July	7,000	48,600	0	48,600	0		48,600
August	3,100	40,800	0	40,800	0		40,800
September	<u>2,900</u>	<u>25,400</u>	<u>0</u>	<u>23,500</u>	<u>1,900</u>		<u>25,400</u>
Totals	21,000	233,000	15,000	209,400	8,600		218,000

The estimated difference between the average annual farm delivery of 72,000 acre-feet under present water supply development and the annual farm delivery of 177,000 acre-feet under operation of the Wilson Valley Project represents the new surface water delivery made available by the project, and amounts to 105,000 acre-feet per year.

The Wilson Valley Project would be operated in conjunction with the ground water storage capacity underlying the Cache Creek Service Area to fully utilize the water supplies made available. This would not involve a deliberate or planned use of the ground water storage capacity; rather, it would involve the pumping and application of the additional ground water supply resulting from percolation of canal and distribution system losses and of the excess application of surface water supplies made available by the project. It was estimated that percolation losses from the mainly unlined canals and distribution system would be about 20 percent of the total diversions from Cache Creek. It was further estimated that these conveyance and distribution losses, plus the percolation of water from excess irrigation application, would provide about 30,000 acre-feet per year of additional ground water recharge, which would be equivalent to 43,000 acre-feet per year on the basis of gross application, or farm delivery. In other words, a net annual ground water supply of 30,000 acre-feet would support a gross pumping draft of 43,000 acre-feet, under an irrigation efficiency of 70 percent. The remaining 13,000 acre-feet, representing excess of applied surface water, would return to ground water.

It should again be emphasized that yield of the Wilson Valley Project was determined as the difference between the total availability of water in the Cache Creek Service Area with the project in operation and the total availability in the service area under present development. It may be recalled that the safe yield of presently developed water supplies in the service area amounts to 232,000 acre-feet per year, and that the Wilson Valley Project would increase this value to 380,000 acre-feet per year, an increase in yield, or project new yield, of 148,000 acre-feet per year. The derivation of project benefits for irrigation and urban water supplies, presented herein, is based upon the differences between project and nonproject conditions, rather than upon only the new yield to be made available by the project.

Projections by decades of land use and water requirements in the Cache Creek Service Area with the Wilson Valley Project in operation are presented in Table 43. Table 43 shows acreages and corresponding water requirements for each of the major irrigated crops for both the major and minor irrigation seasons, and for urban development. The table also indicates the forecast gradual decline in acreage of irrigated lands each decade, which decline is slightly more than offset by an increase in area of urban development which would encroach upon agricultural lands.

The estimated average annual agricultural returns to land and water in the Cache Creek Service Area with the Wilson Valley Project in operation are set forth, by decades, in Table 44. The returns under present water supply development, shown in Table 34, were subtracted from the total returns to obtain the agricultural benefits creditable to the Wilson Valley

TABLE 43

PROJECTED AVERAGE LAND USE AND ANNUAL
WATER REQUIREMENTS, BY DECADES,
IN CACHE CREEK SERVICE AREA
WITH WILSON VALLEY PROJECT

	Average for decade					
	1965-74	1975-84	1985-94	1995-2004	2005-2014	
Land use	: : Water : requirement, : Acreage : in acre-feet : Acreage : in acre-feet : Acreage : in acre-feet	: : Water : requirement, : Acreage : in acre-feet : Acreage : in acre-feet : Acreage : in acre-feet	: : Water : requirement, : Acreage : in acre-feet : Acreage : in acre-feet : Acreage : in acre-feet	: : Water : requirement, : Acreage : in acre-feet : Acreage : in acre-feet : Acreage : in acre-feet	: : Water : requirement, : Acreage : in acre-feet : Acreage : in acre-feet : Acreage : in acre-feet	: : Water : requirement, : Acreage : in acre-feet : Acreage : in acre-feet : Acreage : in acre-feet
<u>Irrigated lands</u>						
Major irrigation season						
Orchard	14,300	37,200	16,940	44,100	16,650	43,300
Alfalfa	23,860	93,100	21,490	83,800	20,000	78,000
Pasture	5,070	21,800	5,040	21,700	4,950	21,300
Truck	38,320	103,400	36,490	98,500	35,460	95,700
Field	37,250	93,100	35,880	89,700	34,920	87,300
Rice	---	---	---	---	---	---
Subtotals	118,800	348,600	115,840	337,800	111,980	325,600
Minor irrigation season						
Truck	7,750	11,600	9,490	14,200	10,060	15,100
Field	4,430	5,800	5,300	6,900	5,650	7,300
Totals	130,980	366,000	130,630	358,900	127,690	348,000
Urban	5,400	14,000	8,040	21,100	11,980	32,000
Totals	136,380	380,000	138,670	380,000	139,670	380,000

TABLE 44

ESTIMATED AVERAGE ANNUAL AGRICULTURAL
RETURNS IN CACHE CREEK SERVICE AREA
WITH WILSON VALLEY PROJECT

	1965-74	1975-84	1985-94	1995-2004	2005-2014
Returns to : land and water, : per acre : (in dollars) : (in acres):(in dollars):(in acres):(in dollars):(in acres):(in dollars)	Average : acreage : during : decade : per decade : (in acres):(in dollars):(in acres):(in dollars):(in acres):(in dollars)	Average : acreage : during : decade : per decade : (in acres):(in dollars):(in acres):(in dollars):(in acres):(in dollars)	Average : acreage : during : decade : per decade : (in acres):(in dollars):(in acres):(in dollars):(in acres):(in dollars)	Average : acreage : during : decade : per decade : (in acres):(in dollars):(in acres):(in dollars):(in acres):(in dollars)	Average : acreage : during : decade : per decade : (in acres):(in dollars):(in acres):(in dollars):(in acres):(in dollars)
Irrigated lands					
Major season					
Alfalfa	41.00	23,860	978,300	21,490	881,100
Pasture	31.60	5,070	160,200	5,040	159,300
Field	57.00	37,250	2,123,300	35,880	2,045,200
Truck	69.00	38,320	2,644,100	36,490	2,517,800
Orchard	92.50	14,300	1,322,700	16,940	1,567,000
Subtotals		118,800	7,228,600	115,840	7,170,400
Minor season					
Truck	104.00	7,750	806,000	9,490	987,000
Field	87.00	4,430	385,400	5,300	461,100
Dry farmed	15.00	4,500	67,500	4,500	67,500
Total agri-cultural returns			8,487,500	8,686,000	8,558,900
Agricultural returns under nonproject conditions (from Table 34)			4,848,100	4,768,700	4,649,000
PROJECT AGRICULTURAL BENEFITS			3,639,400	3,917,300	3,909,900
					4,493,000
					8,153,000
					4,308,000
					3,845,000

Project. Estimates of urban benefits creditable to the Wilson Valley Project are shown in Table 45. These benefits were similarly computed by subtracting urban benefits under present water supply development, presented in Table 35, from total urban benefits with the project in operation, as shown in Table 45.

TABLE 45

ESTIMATED AVERAGE ANNUAL URBAN WATER
BENEFITS IN CACHE CREEK SERVICE AREA
FROM WILSON VALLEY PROJECT

Decade	Average annual urban water requirement :(in acre-feet):	Return, per acre-foot :(in dollars)	Average annual benefits : during decade : under project : conditions :(in dollars)	Average 1/ annual benefits: : under present : water supply : development :(in dollars)	Average annual benefits from Wilson Valley Project during decade :(in dollars)
1965-74	14,000	34	476,000	313,000	163,000
1975-84	21,100	34	717,000	466,000	251,000
1985-94	32,000	34	1,088,000	694,000	394,000
1995-04	46,800	34	1,591,000	993,000	598,000
2005-14	65,100	34	2,213,000	1,343,000	870,000
Totals			6,085,000	3,809,000	2,276,000

1/ From Table 35.

Flood Control. As previously stated, the Wilson Valley Project would be operated to provide flood protection to lands and improvements adjacent to Clear Lake and bordering lower Cache Creek. Flood control adjacent to Clear Lake would be realized by enlarging the Clear Lake outlet channel from the present capacity of 2,500 second-feet with a lake stage of 7.56 feet on the Rumsey Gage, to 8,500 second-feet at the same stage. Enlargement of this channel and modification of the operation of Clear Lake to provide the desired flood protection would necessitate modification of the Bemmerly and Gopcevic Decrees. However, the improved water supply conditions created by the Wilson Valley Project should warrant the required modification of those decrees.

During the floods of February, 1956 and February, 1958, Clear Lake reached stages of 9.6 and 10.9 feet, respectively; measured at the Rumsey Gage. The maximum capacity of the outlet channel at those high stages was about 5,000 second-feet. Routing studies of those floods with the enlarged outlet channel indicated that the maximum lake stage during the flood of February, 1956 would have been 7.0 feet on the Rumsey Gage, and that during the flood of February, 1958 it would have been 8.0 feet. The maximum discharge from Clear Lake at these stages would have been about 9,000 second-feet. A series of flood hydrographs showing stages of Clear Lake for the 1956 and the 1958 floods, as well as for predicted greater floods, both with and without the enlarged outlet channel, is depicted on Plate 16, entitled "Wilson Valley Project, Flood Control Operation".

Wilson Valley Reservoir would be operated to maintain a flood storage reservation of 65,000 acre-feet during the period

from November 1 to April 1, in order to regulate the increased releases from Clear Lake and the flood flows of the North Fork of Cache Creek. This storage would be controlled by a radial gate mounted in the spillway. During higher reservoir stages, the radial gate would be kept open prior to April 1 and closed thereafter, thus permitting use of the flood storage reservation space for conservation after the flood season had ended. From flood routing studies, it was determined that the floods of February, 1956 and February, 1958 could have been completely controlled within the 65,000 acre-foot flood control reservation space. Whereas peak discharges of these floods in Cache Creek at Capay actually reached 30,000 and 52,000 second-feet, respectively, the discharges would have been reduced to 21,000 second-feet by operation of Wilson Valley Reservoir. It was indicated that operation of the reservoir for flood control would reduce the peak discharge of a 1- in 100-year flood at Capay from about 55,000 second-feet to 21,000 second-feet. Correspondingly, the peak discharge of a 1- in 1,000-year flood flow at Capay would be reduced from about 89,000 second-feet to 26,000 second-feet.

During the 1- in 100-year flood, the surcharge storage in Wilson Valley Reservoir would rise to 4.0 feet above the over-pour spillway lip, and during the 1- in 1,000-year flood, it would rise to 6.2 feet above the spillway lip. This degree of control, which would limit flood flows at Capay under most conditions to 21,000 second-feet, would reduce erosion along lower Cache Creek and would materially extend the useful period of use of the Cache Creek settling basin. Flood hydrographs of Clear Lake, Wilson Valley Reservoir, and Cache Creek at Capay under uncontrolled

conditions and project controlled conditions are shown on Plate 17, entitled "Water Levels of Clear Lake and Wilson Valley Reservoir".

Flood control benefits that would accrue from operation of Wilson Valley Reservoir were evaluated using standard frequency methods developed by the Corps of Engineers. These methods involve the preparation of curves showing damage versus flood stage. These data are related to flood frequency data, in order to estimate the average annual flood damages with and without the project. Data from historical floods such as those of February, 1956 and February, 1958 were utilized in the evaluation. For the purposes of estimating flood damages, the project area was subdivided as follows: (1) Reach No. 1, Cache Creek from Yolo Bypass to Airport Road; (2) Reach No. 2, Cache Creek from Airport Road to Capay Dam; (3) Reach No. 3, Cache Creek from Capay Dam to Wilson Valley Dam site; and (4) Reach No. 4, lands adjacent to Clear Lake.

Flood control benefits were estimated, using current (1959) price levels. The estimates included direct and indirect benefits, as well as an evaluation of improved land use that would result under project conditions. No evaluation was made of the secondary benefits that would accrue from operation of the project. Direct benefits would be realized from reduction of damage experienced by occupants of the flood plain, including such items as loss of crops, physical damage to buildings, utilities, roads, and bridges, etc. Indirect benefits would accrue from elimination of financial and business losses sustained by the community outside the area of direct inundation. The estimated benefits were adjusted to reflect anticipated future economic conditions that would prevail during the 50-year project repayment period.

In evaluating flood control benefits it was necessary to utilize adjustment factors or assumptions. In studies of Reach No. 1 it was assumed, from projections of population growth, that the boundaries of Woodland would be contiguous with Cache Creek by 2010. Furthermore, it was assumed that urbanization of the flood plain would be consistent with population growth, and that development would be essentially residential in nature. Using these assumptions, the present worth of potential residential damage was estimated, using a three percent interest rate. In addition to these benefits in Reach No. 1, benefits would accrue from reduction of operation and maintenance of levees and from reduction of sediment transported into the Cache Creek settling basin.

In studies of Reaches No. 2 and No. 3, it was assumed that the future economy would develop at a substantially slower rate than that of the county as a whole. It is believed that the rate of development in these areas will approximate the rate reported in the publication of the Corps of Engineers, "Review Report on Cache Creek Basin", July, 1950.

In the studies of Reach No. 4, the projected future economic development of lands and improvements adjacent to Clear Lake was based on county-wide population projections. This development then was evaluated on a present-worth basis using a three percent interest rate. The amount so derived became the basis of the future damage factor. The use of county-wide growth rates was considered to be a conservative approach, in that it is believed the economic growth adjacent to Clear Lake reasonably can be expected to increase at a more rapid rate than Lake County as a whole.

In studies of the Cache Creek settling basin, pre-project sediment deposition rates were determined from recent surveys of historical quantities of sediment deposited in the basin. It was estimated that under project operation, sediment inflow would be reduced about 60 percent because of reduction of peak flows into the basin. Based on the estimated rates of deposition with and without the Wilson Valley Project, the remaining life of the basin was determined, and the cost of a second basin that would serve as a replacement to the existing basin was estimated. The annual benefit attributable to the project by reduction of sediment transport into the settling basin was measured as the difference in present worth of the costs of the replacement basin for the project and nonproject life periods.

To determine the reduction in levee operation and maintenance costs in Reach No. 1 that would be realized under project operation, a damage-discharge curve similar to the curve for evaluating direct damages was developed. The reduction in costs would be realized from reduction in fighting major floods and in repairing flood damage. No adjustment was made for indirect damages, or for the effect of changes in future economic conditions.

It was estimated that the total average annual equivalent flood control benefits creditable to the Wilson Valley Project would be about \$526,000, of which \$345,000 would accrue to the Clear Lake area and \$180,000 to the lower reaches of Cache Creek. These estimates are shown by major reaches in Table 46.

TABLE 46

ESTIMATED AVERAGE FLOOD CONTROL BENEFITS
ATTRIBUTABLE TO WILSON VALLEY PROJECT

Reach	:Annual equivalent : benefit
No. 1 (Airport Road to Yolo Bypass)	\$ 97,800
No. 2 (Capay Dam to Airport Road)	28,700
No. 3 (Wilson Valley Dam to Capay Dam)	13,400
No. 4 (Lands Adjacent to Clear Lake)	345,000
Cache Creek settling basin	27,300
Lower Cache Creek levee maintenance	<u>13,800</u>
Total	\$526,000

Recreation Benefits. Recreational benefits that would accrue to the Wilson Valley Project were measured by comparing the estimated future recreational activity in the Clear Lake-Cache Creek Basin with and without the project. For purposes of this investigation, recreational benefits were limited to water-associated recreational activity. Such benefits were determined on the basis of projected growth and distribution of population; improved mobility because of better transportation facilities; location of areas of the State from which visitors would come; increased leisure time and psychological need for outdoor recreation; existing recreational opportunities and facilities in the area; possible development of new types of outdoor recreational activity, and relative attractiveness of the area in relation to rival or competing areas.

Results of the studies of increased recreational use were expressed as annual visitor-days. To determine the number of

visitor-days of use of the proposed Wilson Valley Reservoir and of Clear Lake, the department contracted for recreational studies in 1958 with the firm of Wilsey and Ham, Engineers and Planners, Millbrae, California. The results of those studies were presented to the department in a publication entitled "Cache Creek Basin Recreation Study", November, 1958. This study provided the basis for evaluation of recreational benefits that would accrue as a result of project operation.

The monetary value of recreational benefits was based on the consumer surplus theory. Under this theory the net value of recreational enjoyment to the recreationist was evaluated on the basis of cost of travel to and from the recreational area. Other expenditures in the pursuit of recreation enjoyment were considered to represent normal costs of daily living under any circumstances, or to represent prices paid for goods and services which have established market values. From the foregoing considerations a value of \$1.80 was assigned as the monetary benefit of a recreation visitor-day.

Operation of the Wilson Valley Project would enhance recreation around Clear Lake by providing greater stabilization of the lake levels. The effect of project operation on Clear Lake levels may be seen by reference to Plate 17. During most years there would be no draft upon Clear Lake for downstream irrigation use, thus eliminating the low water stages presently experienced during late summer months.

Recreational use of Wilson Valley and Brooks Reservoirs would be improved by installation of onshore recreational facilities and access roads. Moreover, the planned releases of water

from Wilson Valley Reservoir to maintain a minimum flow of 50 second-feet in the channel of Cache Creek would provide a further recreation attraction. Onshore recreation facilities required for development of the recreational potential at Wilson Valley Reservoir are shown in Plate 18, entitled "Proposed Recreation Facilities at Wilson Valley Reservoir".

It was forecast that maximum recreational use of the Wilson Valley Project would accrue within 15 years after construction of the project. The estimated maximum (1980) annual visitor-days of recreation use creditable to the project, based on development of Wilson Valley and Brooks Reservoirs, stabilization of the water level of Clear Lake, and improved stream flow of Cache Creek from Wilson Valley Dam to Brooks Reservoir, are presented in the following tabulation:

	<u>Visitor-days</u>
Wilson Valley Reservoir	763,000
Clear Lake	500,000
Cache Creek	100,000
Brooks Reservoir	<u>80,000</u>
Total	1,443,000

The estimates of resultant recreational benefits are presented by decades in Table 47. It may be noted that the annual visitor-days shown in Table 47 decrease during the latter decades. This is because the project is credited only with net visitor-days of use, or the difference in use between project and nonproject conditions.

TABLE 47

ESTIMATED AVERAGE ANNUAL RECREATION BENEFITS
CREDITABLE TO WILSON VALLEY PROJECT

Decade	:Average annual: : visitor-days : : creditable : : to project	:Average benefit: :per visitor-day:	Average annual benefit, in decade
1965-74	754,000	\$1.80	\$ 1,357,200
1975-84	1,393,000	1.80	2,507,400
1985-94	1,438,000	1.80	2,588,400
1995-04	1,432,000	1.80	2,577,600
2005-14	1,426,000	1.80	2,566,800
Total, for 50 years			\$11,597,400

Summary of Project Accomplishments. Accomplishments of the Wilson Valley Project, expressed as benefits accruing to project operation for irrigation, urban water supply, recreational, and flood control purposes, would aggregate some \$350,000,000 over the 50-year repayment period. Estimates of these benefits are set forth in Table 48 for each of the four project purposes, by decades from 1965 through 2014. It may be noted in Table 48 that a subtraction was made from gross irrigation benefits to obtain net benefits. This subtraction represented the cost of pumping the 43,000 acre-feet of increased ground water supplies which would be made available by the Wilson Valley Project. Based upon estimates furnished by the Yolo County Farm Advisor, a pumping cost of \$4 per acre-foot was assigned for recovery of this water.

TABLE 48

SUMMARY OF ESTIMATED WILSON VALLEY PROJECT BENEFITS

(In thousands of dollars)

Item	Decade				Totals	Average annual equiva- lent
	1965-74	1975-84	1985-94	1995-2004	2005-14	
Total benefits						
Irrigation						
Gross	36,394	39,173	39,099	39,495	38,450	192,611
Cost of ground water pumping	- 860	-1,720	-1,720	-1,720	-1,720	7,740
Net	35,534	37,453	37,379	37,775	36,730	184,871
Urban water supply	1,630	2,510	3,940	5,980	8,700	22,760
Recreation	13,572	25,074	25,884	25,776	25,668	115,974
Flood control	5,260	5,260	5,260	5,260	5,260	26,300
Totals	55,996	70,297	72,463	74,791	76,358	349,905
Present worth factor	0.8219	0.5553	0.3751	0.2534	0.1712	
Present worth of benefits						
Irrigation (net)	29,205	20,788	14,024	9,572	6,288	3,718
Urban water supply	1,340	1,394	1,478	1,515	1,489	336
Recreation	11,155	13,924	9,709	6,532	4,394	2,128
Flood control	4,330	2,930	1,970	1,330	900	530
Totals	46,030	39,036	27,181	18,949	13,071	6,712

In this connection, it should be pointed out that total project benefits over the 50-year project repayment period could not be used as a direct monetary measure of project accomplishments. Rather, this evaluation had to be based on comparison of benefits with project costs on a common-time basis. Since project capital investment would be fully committed by 1965, the assumed year of initial operation, it was necessary to derive the equivalent 1965 value of benefits accruing over the 50-year repayment period. This involved adjustment of the actual benefits for each decade by multiplication by the appropriate "present worth" factor for the particular decade, as shown in Table 48.

The estimated present worth (1965) of project benefits over the 50-year period from 1965 through 2014 is shown in Table 48 to be \$144,300,000. That table also shows the estimated average annual equivalent benefits for each of the project purposes, which values were computed from the total benefits over the 50-year period.

Economic Justification

It is recognized that the development of water resources creates esthetic, social, and other intangible benefits, as well as economic benefits. However, the intangible benefits are not susceptible of measurement in monetary terms, and only the economic benefits are used in evaluating project accomplishments. Economic benefits are compared with project costs to measure economic justification. The degree of economic justification, commonly expressed as the "benefit-cost ratio", is defined as the ratio of project net benefits to project costs.

Overall net benefits of the Wilson Valley Project, as presented in Table 48, and project costs, as shown in Table 41, are recapitulated in the following tabulation. These values provide the basis for computation of the benefit-cost ratio, which also is shown in the tabulation.

Project net benefits (1965 present value)	\$144,267,000
Project costs (including present worth (1965) of annual operation, maintenance, and replacement)	\$ 61,864,000
Benefit-cost ratio	2.33 to 1

A project may be considered to be economically justified if the benefit-cost ratio is greater than unity. However, it is prudent practice that a project have a benefit-cost ratio substantially in excess of unity before the economic justification is sufficient to warrant its construction. It is evident that the Wilson Valley Project, with a benefit-cost ratio of 2.33 to 1, is economically justified by a margin warranting construction.

As stated earlier in this chapter, the Wilson Valley Project was formulated on the basis of net benefits created. The project described herein, which includes 1,000,000 acre-feet of storage in Wilson Valley Reservoir, was selected as the size which would provide the maximum net benefits to the Clear Lake-Cache Creek Basin. While the benefit-cost ratio of a slightly smaller reservoir would be slightly greater than 2.33 to 1, the net benefits would not be as large. The reduction in net benefits from a smaller project would result from a decrease in new yield of water for irrigation and urban purposes. Moreover, a substantial decrease in supplemental irrigation and urban water supplies by

construction of a smaller Wilson Valley Project would necessitate the development of an additional source of water for the Cache Creek Service Area in the relatively near future.

Allocation of Project Costs

Cost allocation is the process of apportioning costs of a multipurpose project equitably among the various purposes served by the project. This is an essential step in the economic evaluation, in that it provides a basis for determination of repayment by project beneficiaries for the various project services. The allocation embraces all project costs, including those for construction, operation, maintenance, and replacement. The concept of cost allocation is founded on the basic premise that the total cost of combining several purposes in a comprehensive multipurpose project is substantially less than the sum of the costs of separate projects provided for each purpose, and that the savings derived through use of multipurpose structures should be shared by all purposes.

While there are several methods available for allocating costs of a multipurpose project, the "separable costs-remaining benefits" method is generally considered to be superior to other methods with respect to projects such as the Wilson Valley Project. Consequently this method, which has been recommended by the Federal Interagency Committee on Water Resources for general use in allocating costs of federal multipurpose river basin projects, was adopted for the Clear Lake-Cache Creek Basin Investigation. Briefly, the separable costs-remaining benefits method involves determination of the separable costs of each project purpose, or

the added cost of including the purpose in the project; evaluation of the benefits accruing to each purpose, such benefits being limited by alternative costs; and, by subtracting the separable cost from the benefits for each purpose, the assignment to each purpose of a share of the residual or remaining joint costs in proportion to the remaining benefits. The procedure in allocation of costs by this method consists of the following steps.

1. Evaluation of the net benefits accruing to each project purpose, represented as gross benefits less associated costs.

2. Determination of the alternative cost of a single-purpose project which would provide equivalent benefits for each purpose. The method of such determination and the resultant cost of an alternative for each purpose is shown in Table 49.

3. Assignment as benefits for each purpose the lesser value of the benefits from step 1 and the alternative single-purpose cost from step 2.

4. Determination of the difference between the total cost of the multipurpose project and the cost of the project with the purpose omitted. This is designated the "separable" cost. The method of such determination and the resultant separable cost for each purpose is set forth in Table 50.

5. Derivation of the remaining benefits by subtraction of the separable cost, from step 4, from the benefits limited by alternative cost, from step 3.

TABLE 49

SUMMARY OF SINGLE-PURPOSE ALTERNATIVE PROJECTS FOR WILSON VALLEY PROJECT COST ALLOCATION

Purpose	General description	Costs		Capital cost, including present worth of operation and maintenance		Total benefits		Benefit-cost ratio
		Capital	Annual	Capital	Annual	benefits	cost	
Irrigation	Wilson Valley Dam and Reservoir with 1,000,000 acre-feet of storage capacity, and spillway without flood control features; Brooks Reservoir; and acquisition and improvements of distribution system; Clear Lake outlet enlargement and recreation facilities omitted; no reduction made for 50,000 acre-foot minimum pool as recreation feature.	\$38,185,000	\$2,441,000	\$48,221,000		\$79,877,000	1.65	
Urban	Ultimately 30,000 acre-feet annually required from surface water, and 56,000 acre-feet from ground water; 150,000 acre-foot storage capacity reservoir at Indian Valley site; primary treatment plant at Capay, and 16-mile pipeline to Woodland.							
Recreation	1. Wilson Valley Reservoir with 150,000 acre-feet of storage capacity to provide recreation use; 50,000 acre-foot minimum pool; 24,000 acre-foot annual yield for partial replacement of Clear Lake yield; 4,000 acre-feet of annual yield for stream flow maintenance; capital cost of \$12,183,000. 2. Indian Valley Reservoir, with 200,000 acre-foot storage capacity; 48,000 acre-foot annual yield for replacement of Clear Lake yield and to limit surface fluctuation; on-shore facilities at Wilson Valley Reservoir and Clear Lake; capital cost of \$3,900,000. 3. Onshore recreation facilities with a capital cost of \$1,750,000 at Wilson Valley and \$930,000 at Clear Lake.	\$7,000,000	\$554,000	\$11,500,000		\$7,216,000	0.63	
Flood control	Single-purpose flood control reservoir at Wilson Valley site with 150,000 acre-foot storage capacity; ungated, side channel spillway designed for 63,000 cubic feet per second maximum discharge with 15-foot surge; flood control releases up to 15,000 cubic feet per second through a gated, 28-foot diameter tunnel structure; enlargement of Clear Lake outlet channel.	\$18,763,000	\$1,289,000	\$27,039,000		\$45,714,000	1.69	
		\$14,560,000	\$791,000	\$16,995,000		\$11,460,000	0.67	

TABLE 50

SUMMARY OF ESTIMATES OF SEPARABLE COSTS FOR WILSON VALLEY PROJECT COST ALLOCATION

Purpose	General description	Capital cost	Capital cost, including present worth of operation and maintenance	Separable cost	Total benefits and benefits for separable purpose	Benefit-cost ratio
Multipurpose	Wilson Valley Reservoir with 1,000,000 acre-feet of storage capacity; Brooks Reservoir; acquisition and improvement of distribution system; recreation features and facilities; flood control features at Wilson Valley Reservoir; and Clear Lake outlet enlargement.	\$45,010,000	\$61,864,000		\$144,267,000	2.39
Irrigation	Wilson Valley Reservoir with 300,000 acre-feet of storage capacity to deliver 23,000 acre-feet annually for urban use and 4,000 acre-feet per season for stream flow maintenance; recreation and flood control features included; irrigation omitted.	\$25,867,000	\$34,714,000	\$27,150,000	\$ 79,877,000	2.94
Urban	Wilson Valley Reservoir with 850,000 acre-feet of storage capacity to deliver 220,000 acre-feet annually for irrigation; recreation and flood control features included; urban water supply omitted.	\$42,573,000	\$59,112,000	\$ 2,752,000	\$ 7,216,000	2.62
Recreation	Wilson Valley Reservoir with 934,000 acre-feet of storage capacity to conserve 250,000 acre-feet annually and to provide flood control; recreation omitted. (Reservoir not operated to reduce Clear Lake fluctuation.)	\$41,066,000	\$51,579,000	\$10,285,000	\$ 45,714,000	4.45
Flood control	Wilson Valley Reservoir with 935,000 acre-feet of storage capacity operated to provide conservation and recreation; Brooks Reservoir, distribution system, and recreation facilities included; flood control omitted. (Flood control storage, reservation of, flood control spillway, and Clear Lake outlet omitted.)	\$42,112,000	\$58,514,000	\$ 3,350,000	\$ 11,460,000	3.42

6. Determination of the total allocated residual cost by subtraction of the total of the separable costs for all purposes from the total project cost, and the proportioning of the allocated residual cost for each purpose in accordance with the distribution of the remaining benefits, as determined from step 5.

7. Determination of the total allocated cost for each purpose as the sum of the separable cost (step 4) and the allocated residual (step 6). It may be noted that the total allocated cost (\$61,864,000) is taken directly from Table 41, and represents the total capital cost of the Wilson Valley Project, plus the present worth of operation, maintenance, and replacement costs over the 50-year repayment period.

8. Subtraction from the total allocated cost to each purpose the present worth of annual operation, maintenance, and replacement for each purpose (detailed in Table 41) to obtain the total capital cost to be allocated to each purpose, shown as item 9 in Table 51.

Allocation of costs of the Wilson Valley Project in accordance with the eight steps outlined is set forth in Table 51. The derivation of the allocated costs in Table 51 can be followed by reference to the foregoing eight steps, which correspond to the numbered items in that table.

TABLE 51

ALLOCATION OF COSTS OF WILSON VALLEY PROJECT

(In thousands of dollars)

Item	: Irrigation :	: Urban :	: Recreation :	: Flood :	Totals
(1) Benefits	79,877	7,216	45,714	11,460	144,267
(2) Alternative single-purpose project	48,221	11,500	27,039	16,995	103,755
(3) Benefits limited by single-purpose cost	48,221	7,216	27,039	11,460	93,936
(4) Separable cost	27,150	2,752	10,285	3,350	43,537
(5a) Remaining benefits	21,071	4,464	16,754	8,110	50,399
(5b) Percent remaining benefits	41.81	8.86	33.24	16.09	100
(6) Allocated residual	7,662	1,624	6,092	2,949	18,327
(7) Total allocated cost	34,812	4,376	16,377	6,299	61,864
(8) Present worth of annual costs	9,477	392	6,361	624	16,854
(9) TOTAL ALLOCATED CAPITAL COSTS	25,335	3,984	10,016	5,675	45,010

Financing and Repayment of Project Costs

The beneficiaries of a public multipurpose project generally embrace a broad sphere of interests, reflecting all levels of government. Certain long-standing federal policies have established the Federal Government--or the people of the United States--as participants for those project services in the national interest. Recently established state policy has similarly declared the State to be a participant in local as well as statewide projects for those project services in the interest of the people of California. Finally, repayment of those project services of local impact properly fall within the responsibility of local government.

The costs allocated to each of the several purposes of the Wilson Valley Project, as set forth in Table 51, constituted the basis for determination of repayment by the project beneficiaries. Cost allocation among project purposes was followed by identification of the beneficiaries, and the assignment of costs to those beneficiaries in proportion to the benefits received.

Having identified the various project beneficiaries of the Wilson Valley Project, and determined the financial extent to which each should participate in the total project costs, the final step concerned the evaluation of financial feasibility, or the ability and willingness of the beneficiaries to repay their allocated costs. This section discusses the factors influencing the allocation of project costs to the various beneficiaries, sets forth the assumptions upon which such allocation was made, and evaluates the cost of project water to the local agency under the adopted assumptions.

Identification of Project Beneficiaries. Federal policy declares that flood control is in the national interest and that the Federal Government, acting through the agency of the Corps of Engineers, will contribute on a nonreimbursable basis the costs of a project which are properly allocable to flood control. The amount of federal financial participation in the Wilson Valley Project in the interest of flood control would be dependent upon results of study by the Corps of Engineers, and upon congressional appropriation of the funds recommended by the corps. Based upon the allocation shown in Table 51, it was assumed that the Federal Government would participate as a beneficiary in the Wilson Valley Project in the interest of flood control in an amount of \$5,765,000.

The State of California, pursuant to the Davis-Grunsky Act (Section 12880 of the Water Code), gives recognition to recreation and the enhancement of fish and wildlife as within the State interest, and provides for nonreimbursable grants to local projects in which such purposes are incidental to the primary functions of the project. Under this policy declaration, the State could participate as a beneficiary in the Wilson Valley Project in the interest of enhancement of recreation, and could contribute a grant representing this State interest, as discussed in the next paragraph.

The cost of the Wilson Valley Project allocated to recreation is shown in Table 51 to be \$10,016,000. However, the Davis-Grunsky Act limits recreation grants to the portion of project construction costs properly allocated to enhancement of recreation, and excludes the cost of onshore recreation facilities.

The cost of onshore recreation facilities, which must be financed from local or other sources, is shown in Table 41 to be \$2,680,000. Therefore, the State, in the interest of recreation, could grant the difference between the allocation shown in Table 51 and the cost of onshore recreation facilities, or \$7,336,000.

Construction of Wilson Valley Dam and Reservoir would require relocation of State Highway 20, which traverses the valley floor in the upper reaches of the reservoir area. The State Division of Highways has indicated its intention to improve Highway 20 to expressway standards within the next few years. Relocation of the highway to existing standards properly would be a responsibility of the Wilson Valley Project. However, betterment of the relocated road to expressway standards should be a responsibility of the State of California, through the California Highway Commission. The State Division of Highways has determined the cost of betterment of the relocated road to expressway standards to be \$1,735,000, and has indicated that this added cost would be contributed on a nonreimbursable basis.

Local public agencies in Yolo and Lake Counties would derive the entire benefits from use of the irrigation, municipal, and industrial water supplies from the Wilson Valley Project. Therefore, those agencies should properly bear the project costs allocated to those purposes, which costs are shown in Table 51 to be \$25,300,000 and \$4,000,000, respectively. In addition, the local agencies would be expected to repay all other project costs not allocated to either the Federal or State Governments.

The Yolo County Flood Control and Conservation District has expressed interest in the Wilson Valley Project, and has

indicated willingness to finance the project with local funds to the full practicable limit of local financing capability. Lands and improvements within the district have a total assessed valuation of about \$90,000,000. Considering existing overlapping indebtedness, it was estimated that a realistic bonding capacity of the district for general obligation bonds in support of the project, at a reasonable interest rate, would be about \$20,000,000. Financial participation in the project by Lake County would add to this figure.

Possible Sources of Financial Assistance. In addition to the possible sources of nonreimbursable contributions mentioned in the foregoing paragraphs, funds for water development projects can be made available on a loan basis from the Federal Government, through the Bureau of Reclamation of the Department of the Interior, and through the Soil Conservation Service of the Department of Agriculture. However, it appears that the only governmental assistance program under which the Wilson Valley Project could qualify would be that authorized by the State Davis-Grunsky Act (Section 12880 of the Water Code).

1. Assistance by Federal Government. Public Law 984, (84th Congress) provides for federal loans to small irrigation projects, upon approval of an application to the Bureau of Reclamation. In order to qualify for such a loan, the project must be primarily for irrigation purposes and its costs must not exceed a total of \$10 million, of which one-half or a maximum of \$5 million may be provided from federal funds. The portion of the loan attributable to the irrigation of lands held in 160 acres

or less in a single ownership is interest free. Because the estimated cost of the Wilson Valley Project is in excess of \$10 million, it would not qualify under the Public Law 984 program.

Public Law 566 (83rd Congress), amended by Public Law 1018 (84th Congress), authorizes the Secretary of Agriculture to cooperate with state and local public agencies in the planning and construction of works for flood prevention and for agricultural phases of conservation, utilization, and disposal of water. This act provides for a maximum loan of \$5 million, subject to congressional approval based on a finding by the Secretaries of Agriculture, Interior, and Army. However, the act limits the storage capacity of projects to 25,000 acre-feet. The size of the Wilson Valley Project (1,000,000 acre-feet) precludes assistance under this program.

Several other possible sources of federal financing are available for local project assistance. However, none of these applies in the case of the Wilson Valley Project. These include Public Law 858 (80th Congress), as amended by Public Law 685 (84th Congress), which provides for allocation of a maximum of \$400,000 for construction of small flood control projects not specifically authorized by Congress; and Public Law 345 (84th Congress) which provides loan assistance for public facilities, through the Housing and Home Finance Agency.

2. State Financial Assistance. The Legislature, in adopting the Davis-Grunsky Act, has declared a policy of providing financial assistance to public agencies for the construction of water projects to meet local needs in which there is state interest.

The Davis-Grunsky Act provides loans for projects primarily for domestic, municipal, agricultural, or industrial purposes, to meet that portion of the cost which is beyond the reasonable ability of an agency to finance from other sources. The Director of Water Resources can make loans of up to a maximum of \$4 million, with approval of the California Water Commission. Loans greater than \$4 million may be made by the department only upon specific authorization of the Legislature and upon such terms and conditions as the Legislature may prescribe. The interest rate charged on loans would approximate the rate paid by the State on its general obligation bonds, and under prevailing conditions would be expected to be on the order of 4 percent. The repayment period would normally be limited to 50 years.

As has been previously mentioned, the Davis-Grunsky Act also provides for nonreimbursable grants for the incidental recreational and/or fish and wildlife enhancement benefits of local water projects. These grants are limited to the costs of a dam and reservoir properly allocated to the recreation and/or fish and wildlife functions. The grants cannot cover the cost of onshore recreational facilities needed to accommodate recreational use. The Director of Water Resources can make grants up to \$300,000, with approval of the California Water Commission. Grants greater than \$300,000 may be made by the department only upon specific authorization of the Legislature and upon such terms and conditions as the Legislature may prescribe.

The Wilson Valley Project appears to meet the necessary qualifications for state financial assistance under the Davis-Grunsky Act. However, the extent of state financial assistance

could be determined only after submission of an application to the Department of Water Resources for such assistance, and, if in excess of the described statutory limitations, after action by the Legislature upon the recommendation of the department.

Federal Construction. Because of the magnitude of costs of the Wilson Valley Project, federal financial assistance to the project could be provided only by specific congressional appropriation. Should local interests desire such assistance, it would be appropriate that the responsible local agency request the Bureau of Reclamation to construct the Wilson Valley Project, just as that agency constructed the Monticello Project on Putah Creek. The decision as to whether a request for federal construction of the Wilson Valley Project should be made is properly one for local interests to make.

In reaching a decision regarding a request for federal construction, the local agency would have to weigh the relative advantages and limitations. The cost of water would be quite favorable, because of the federal policy of interest exemption on repayment for irrigation water. However, under federal construction of the Wilson Valley Project, Reclamation Law would govern and the acreage limitation provisions would apply. Moreover, there could be a considerable lapse of time between the time of request and the time when federal funds would become available by congressional appropriation.

Repayment of Reimbursable Costs. Based upon the estimated cost of constructing the initial features of the Wilson Valley Project and the cost allocation heretofore discussed, it appears that the local construction agency would incur a total

reimbursable cost of about \$27 million. While costs could be repayed through a tax levy, it was assumed that repayment would be secured through revenues from project services. Such revenues would be derived principally from the sale of irrigation and urban water supplies; however, nominal revenues could be realized through recreation tolls. For purposes of this bulletin, only the revenues from irrigation and urban water sales were considered.

Derivation of the reimbursable cost of the initial stage of the Wilson Valley Project is set forth in the following tabulation. The initial stage excludes Brooks Dam and Reservoir and the second phase of the distribution system, both of which features could be deferred for some 20 years and financed at that time by other means.

Estimated project costs, initial stage

Wilson Valley Dam and Reservoir	\$34,515,000
Clear Lake Outlet Channel Enlargement	\$ 1,250,000
Distribution System, first phase	\$ 3,039,000
Onshore recreation facilities	\$ <u>2,680,000</u>
Total	\$41,484,000

Estimated nonreimbursable contributions

Flood Control (Federal Government)	\$ 5,765,000
Highway betterment (State) California Highway Commission	\$ 1,735,000
Recreation grant (State, Davis-Grunsky)	\$ <u>7,336,000</u>
Total	\$14,836,000

Estimated reimbursable cost to be borne by local agency	\$26,648,000
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Assuming that the project reimbursable costs would be repayed through the sales of irrigation and urban water, and proportioning the reimbursable costs between those two purposes in accordance with their relative allocation from Table 51, the average cost of water over the 50-year repayment period would be about \$8 per acre-foot for irrigation and \$19 per acre-foot for urban uses. The payment capacity for irrigation water, considering the projected future crop pattern in the Cache Creek Service Area, was determined to be about \$12.50 per acre-foot; and the payment capacity for urban water was previously determined to be \$34 per acre-foot. From comparison of these estimated values, it is evident that the payment capacities substantially exceed the water charges necessary to fully repay the reimbursable costs plus operation, maintenance, and replacement costs over the 50-year repayment period.

Under a conservative assumption that the State would not make a grant to the Wilson Valley Project in the interest of recreation, the reimbursable project costs would be about \$31 million, assuming that the local agency would eliminate the onshore recreation facilities. The resultant unit costs of irrigation and urban water supplies would be about \$9 and \$22, respectively, which costs would still be well within the respective estimated payment capacities.

In both of the foregoing cases, the local agency would require a substantial loan, in addition to the estimated \$20 million local bonding capacity, in order to finance the Wilson Valley Project. Under the first assumption, a loan of \$7 million would be required, whereas under the latter assumption, a loan of

\$11 million would be required. Assuming an interest rate of 4 percent for the local general obligation bonds and for the additional loan, the project would be financially feasible both with and without a state recreation grant.

Possible Alternative Plans for Water Development

This section discusses a possible plan for increasing yield of the Wilson Valley Project by planned operation of ground water storage in the Cache Creek Service Area; describes a possible alternative to the Wilson Valley Project which would develop supplemental irrigation and urban water for the Cache Creek Service Area; and presents an alternative proposal for operation of Clear Lake for flood control. The first listed of these plans is not really an alternative, but, rather, is an adjunct to the Wilson Valley Project in that it would conserve otherwise uncontrolled winter runoff by use of underground storage capacity underlying the Cache Creek Service Area.

Planned Operation of Ground Water Storage

In addition to yield that could be developed by the Wilson Valley Project operated as described in the foregoing section, it would be possible to secure additional yield by operation of ground water storage in conjunction with diversion of spills from Brooks Reservoir during winter seasons of surplus water. In effect, this plan would use underground storage capacity in the Cache Creek Service Area to conserve an increment of runoff which would otherwise waste from the basin.

Planned operation of ground water storage would necessitate two deliberate activities: (1) Increased pumping from ground water by overlying users in the Cache Creek Service Area, thus creating storage capacity for replenishment; and (2) Diversion of surplus winter flows in Cache Creek for ground water replenishment either by percolation in artificial spreading basins, percolation from canals and laterals which could be kept full during winter months, or, possibly, by winter irrigation, or by combinations of all three methods.

While the incremental yield which could be developed by planned operation of ground water storage was not evaluated during the current investigation, it may be recalled that the annual firm yield which could be developed by the Wilson Valley Project would come within 15,000 acre-feet of meeting the ultimate (2015) supplemental requirement in the Cache Creek Service Area. Although spills from Wilson Valley Reservoir would be infrequent, there is substantial tributary runoff below the dam, which would be partially regulated in Brooks Reservoir. The spills from Brooks Reservoir, therefore, would definitely offer a possibility for development of additional yield in the manner just described. This plan is believed worthy of more definite study after experience is gained from operation of the Wilson Valley Project.

The plan for operation of ground water storage in the Cache Creek Service Area would involve a relatively uniform increased draft from season to season, with replenishment from a widely varying supply of surplus surface water. As a result, ground water levels would be drawn down during years lacking surplus surface water and raised during years of surplus. It is

probable that pumping lifts under such operation would vary between wider limits than those that have occurred in the past, especially toward the end of a lengthy period of little or no surplus surface flows. Therefore, success of the planned operation of the ground water basin would be contingent upon voluntary participation by overlying ground water users, and upon direction of the operation by a basin-wide or county-wide water service agency.

Alternative Cache Creek-Sacramento River Diversion Project

A supplemental water supply for the Cache Creek Service Area could be developed by operation of storage on Cache Creek in conjunction with ground water storage in the service area and a diversion from the Sacramento River. The Cache Creek water supply would include the presently developed supply from Clear Lake, amounting to 72,000 acre-feet per year on a firm basis, and a new firm annual supply of about 48,000 acre-feet from the proposed Indian Valley Reservoir on the North Fork of Cache Creek. It was assumed that ground water would be utilized in the amount of the present annual safe yield of 160,000 acre-feet, plus an additional annual amount of 43,000 acre-feet which would be made available through percolation of the additional surface supplies during the process of delivery and application. Under these conditions, importation of 100,000 acre-feet of water per year, including canal losses, would be required from the Sacramento River.

The Cache Creek-Sacramento River Diversion Project would consist of a dam and reservoir on the North Fork of Cache Creek at the Indian Valley site about 8 miles northeast of Clearlake

Oaks; a regulatory reservoir at the downstream Brooks site, as proposed under the Wilson Valley Project; acquisition and extension of the distribution system of the Clear Lake Water Company, essentially as proposed under the Wilson Valley Project; and an import system comprising a diversion from the Sacramento River at the town of Knights Landing, and conveyance works leading southward to the Moore Canal west of Woodland. The location of these facilities is shown on Plate 12.

Water released from Clear Lake and from Indian Valley Reservoir, as well as available unregulated flow from downstream tributaries, would serve the Cache Creek Service Area through the diversion and distribution system presently operated by the Clear Lake Water Company. Supplemental water would be delivered to lands in the Capay Valley and Hungry Hollow Units, and to lands in the Winters Unit, lying generally above an elevation of 110 feet. Water diverted from the Sacramento River would supply the Moore Unit and lands in the western portion of the Winters Unit lying generally below an elevation of 110 feet. Releases of the imported water to the Moore Canal system would replace most of the present diversion from Cache Creek. The conveyance system for the Sacramento River Diversion would deliver the water southward across the Winters Unit, from a point about midway between Woodland and Madison, to one about midway between Davis and Winters.

Indian Valley Dam and Reservoir. Indian Valley Reservoir, as shown on Plate 12, would be created by a dam on the North Fork of Cache Creek in Section 9, Township 14 North, Range 6 West. This location, at the downstream end of Indian Valley, is

about 8 miles northeast of Clearlake Oaks. Because of the constricted canyon at the dam site and the flat valley area immediately upstream, a reservoir at this site has been proposed many times in the past. Plans presented in this bulletin were based upon studies made during formulation of The California Water Plan. However, cost estimates were revised to reflect 1960 price levels.

Indian Valley Reservoir would have a gross storage capacity of 200,000 acre-feet and a surface area of 3,400 acres at the spillway lip elevation of 1,457 feet, U. S. Geological Survey datum. The reservoir would regulate runoff of the North Fork of Cache Creek to provide a firm seasonal yield of 48,000 acre-feet. Water would be released into Cache Creek to be diverted at the Capay Diversion Dam.

Topographic maps of the Indian Valley Dam site and reservoir area were prepared in 1946 by the U. S. Bureau of Reclamation, using photogrammetric methods. The dam site was mapped at a scale of 1 inch equals 50 feet, with a contour interval of 5 feet, and the reservoir area was mapped at a scale of 1 inch equals 400 feet, with a contour interval of 10 feet. Storage capacities and corresponding surface areas of Indian Valley Reservoir at various stages of water surface elevation are shown in Table 52.

TABLE 52

AREAS AND CAPACITIES OF INDIAN
VALLEY RESERVOIR

Water surface elevation, in feet USGS datum	:	:	:	Storage capacity, in acre-feet
	:	Area, in acres	:	
1,290		0		0
1,320		120		2,000
1,340		420		7,000
1,360		680		17,500
1,380		1,000		35,000
1,400		1,450		59,000
1,420		2,180		95,000
1,440		2,820		146,000
1,460		3,400		207,000
1,480		3,850		280,000

Preliminary engineering geologic investigation by the department shows the Indian Valley Dam site to be geologically suitable for construction of either an earthfill or a concrete-gravity dam up to 200 feet in height. Bedrock at the dam site consists for the most part of meta-sedimentary rocks such as graywacke, sandstone, schist, and slate shale; but meta-volcanic rocks, serpentine, and quartz were also noted. The bedrock, where freshly exposed near the base of the abutments, does not appear to be badly fractured. While beds higher on the abutments appear fractured, drill cores from the left abutment show that such fractures, having occurred from weathering, have not penetrated to any great depth. However, high on the right abutment there

appears to be a considerable, although undetermined, depth of slide-accumulated overburden, which would require removal.

The channel section is quite clean, and shows fresh, hard, good quality rock that is suitable to support any type of structure. Preparation of the channel foundation for a dam of the height considered would require only the removal of a small amount of channel fill material, shaping of the bedrock, and some grouting.

Several types of material are available for dam construction within a reasonably short haul distance of the dam site. Channel deposits upstream from the site contain a large volume of sand and gravel, suitable for placement in the stability section of a zoned dam, and possibly suitable for concrete aggregate. Material for a random fill structure may be provided by the alluvial terraces, composed of fine sand, gravel, and clay, which flank the valley. Residual soils could be stripped from the hillsides for use as impervious fill. There is an unlimited supply of hard, dense volcanic rocks in the hill west of the site, which would be suitable for rockfill, or possibly concrete aggregate.

Indian Valley Dam, as designed for cost estimating purposes, would be a zoned earthfill structure 190 feet in height from stream bed to crest, with a crest length of 600 feet. The dam would contain a central impervious compacted earth core with 1 to 1 side slopes, and outer pervious sections of earth and rock with side slopes of 2.5 to 1. The total volume of embankment would be 730,000 cubic yards.

An ungated, ogee-type, concrete spillway, with concrete-lined approach and discharge channels, would be constructed through

the left abutment of the dam. The spillway was designed to pass a maximum flood discharge of 20,000 second-feet.

The outlet works would consist of a 4.5-foot diameter steel pipe, encased in concrete in a cut-and-cover section through the right abutment of the dam. The outlet would be controlled by hydraulically operated gate valves.

Inundation of Indian Valley would necessitate relocation of about four miles of county road. For access, about six miles of improved road would have to be constructed from State Highway 20 to the dam site.

Most of the lands in Indian Valley that would be flooded by the reservoir are classed as irrigable. However, there is little intensive agricultural development in the valley because of limited access and lack of reliable water supply.

Pertinent data with respect to general features of the Indian Valley Dam and Reservoir, as designed for cost estimating purposes, is presented in Table 53. A summary of the cost estimate is shown in Appendix B. It was estimated that the capital cost of Indian Valley Dam and Reservoir would be about \$3,900,000. The corresponding annual cost at four percent interest would be \$230,000.

TABLE 53

GENERAL FEATURES OF
INDIAN VALLEY DAM AND RESERVOIR

<u>Dam</u>	
Type	earthfill
Crest elevation, in feet	1,470
Crest length, in feet	600
Crest width, in feet	30
Height of crest above stream bed, in feet	180
Freeboard, in feet	13
Side slopes	
Upstream	2.5:1
Downstream	2.5:1
Elevation of stream bed, in feet	1,290
<u>Reservoir</u>	
Spillway lip elevation, in feet	1,457
Surface area at spillway lip, in acres	3,400
Storage capacity at spillway lip, in acre-feet	200,000
Drainage area, in square miles	121
Average seasonal runoff, in acre-feet	89,300
Seasonal yield of water, in acre-feet	48,000
Type of spillway	Ungated ogee weir and concrete- lined chute located on left abutment
Spillway discharge capacity, in second-feet	19,400
Type of outlet works	6-foot diameter reinforced concrete conduit through right abutment

Sacramento River Diversion. The Sacramento River

Diversion would consist of four pumping lifts and four canal reaches. It would originate at Knights Landing and terminate at Putah Creek about eight miles west of Davis. Pumping Plant No. 1, located at the point of initial diversion at Knights Landing, would pump from the Sacramento River at an average elevation of about 18 feet, and discharge into the Colusa Basin drainage canal. This existing channel would convey the diverted

water northwesterly about 4.5 miles to Canal Reach No. 1. In this canal reach the water would flow about four miles in a southerly direction from the south bank of the Colusa Basin drainage canal to Pumping Plant No. 2, located two miles north of Yolo.

From Yolo, Canal Reach No. 2 would extend southerly about three miles to Pumping Plant No. 3, located at the town of Yolo on the north bank of Cache Creek. Pumping Plant No. 3 would discharge into a penstock which would also act as a siphon under Cache Creek. Canal Reach No. 3 would course southerly from Cache Creek about three miles to the vicinity of Willow Oak School, then westerly about two miles to the Moore Canal.

Pumping Plant No. 4 would be located at the end of Canal Reach No. 3, about three miles west of Woodland. This plant would discharge into both the Moore Canal and Canal Reach No. 4. This last reach would cross the service area in a southerly direction at an elevation of approximately 110 feet. The size of the canal would decrease from north to south from an initial discharge capacity of 400 second-feet to a terminal capacity of 80 second-feet because of en route releases to the distribution system. The canal would terminate in Willow Canal on the north bank of Putah Creek at a point about 8 miles west of Davis.

The water supply for the Sacramento River Diversion would come partly from the Sacramento River and partly from the Colusa Basin drainage canal. In most years an ample supply of irrigation return flow is available in the Colusa Basin drainage canal. This return flow originates from the large quantities of water diverted from the Sacramento River to irrigate rice in the Colusa Basin. Although the water has been used, the quality is

still adequate for irrigation. Pumping Plant No. 1 would be required to pump water from the Sacramento River in sufficient quantities to create a northwestward flow in the Colusa Basin drainage canal.

The canals would be concrete lined to minimize seepage losses. Details of those reaches are shown in the following tabulation:

<u>Reach</u>	<u>Length, in feet</u>	<u>Discharge capacity, in second- feet</u>	<u>Slope</u>	<u>Water surface elevation in feet</u>	<u>Canal bottom width</u>	<u>Total depth, in feet</u>
No. 1	22,000	400	0.000055	21.5-20.3	13	8
No. 2	19,100	400	0.000055	56-54.4	13	8
No. 3	23,700	400	0.000055	80-77.1	13	8
No. 4	70,200	330 to 80	0.00008 to 0.00014	110-103.3	10 to 5.2	7 to 3.6

The four pumping plants would be capable of discharging sufficient water to meet the maximum monthly irrigation requirement. Plants Nos. 2, 3, and 4 would be essentially constant-head plants, while Plant No. 1 would operate over a considerable head range because of variations in river stage. Characteristics of the pumping plants are shown in the following tabulation:

<u>Pumping plant</u>	<u>Installed electric capacity, in kilowatts</u>	<u>Discharge capacity, in second- feet</u>	<u>Annual electric power consumption, in kilowatt- hours</u>	<u>Maximum static head, in feet</u>	<u>Average static head, in feet</u>
1	510	400	370,000	10.5	5
2	1,750	400	5,350,000	36.2	36.2
3	1,260	400	3,900,000	26.1	26.1
4	1,610	400	5,000,000	33.4	33.4

Summary of Project Costs. The overall capital cost of the Alternative Cache Creek-Sacramento River Diversion Project was estimated to be \$17,498,000. The corresponding annual cost was estimated to be \$1,859,000, based upon a repayment period of 50 years at an interest rate of 4 percent, and including the annual costs of operation, maintenance, and replacement. A summary of the estimated costs of the principal facilities comprising the project is shown in the following tabulation:

	<u>Capital costs</u>	<u>Annual costs</u>
Indian Valley Dam and Reservoir	\$ 3,976,000	\$ 219,000
Brooks Dam and Reservoir	1,819,000	98,000
Distribution System	4,746,000	529,000
Sacramento River Diversion	6,957,000	663,000
Delta Water Charge	<u> </u>	<u>350,000</u>
Totals	\$17,498,000	\$1,859,000

It may be noted that a "Delta Water Charge" was included as an annual cost. This represents the basic charge to all users of water from the State Water Facilities, as defined in the California Water Resources Development Bond Act (Burns-Porter Act) which authorized the issuance of \$1.75 billion in general obligation bonds of the State of California for financing construction of those facilities. In this regard, it should be recognized that there is no firm supply of water in the Delta at the present time, and that any additional diversions from the Delta on a firm basis will necessitate construction of conservation features of the State Water Facilities. Under payment provisions in the contract between the State and The Metropolitan Water District of Southern California, the Delta water charge is to be set at

\$3.50 per acre-foot until 1969, \$4.68 per acre-foot from 1970 to 1981, and \$6.30 per acre-foot after 1981.

Summary of Project Accomplishments. The Alternative Cache Creek-Sacramento River Diversion Project, including presently developed water supplies, would provide 395,000 acre-feet of water per season to fully meet potential ultimate supplemental water requirements in the Cache Creek Service Area. In terms of annual net farm delivery, 203,000 acre-feet would be supplied from ground water and 192,000 acre-feet from surface water sources. The surface water supply would comprise 110,000 acre-feet from Cache Creek and 82,000 acre-feet from the Sacramento River. The gross annual delivery of new water to the Cache Creek Service Area by this project would consist of 48,000 acre-feet from Indian Valley Reservoir and 100,000 acre-feet from the Sacramento River Diversion.

The estimated average annual deliveries of agricultural and urban water to the Cache Creek Service Area by the Alternative Cache Creek-Sacramento River Diversion Project are shown, by decades, in Table 54.

TABLE 54

AVERAGE ANNUAL WATER DELIVERIES TO
CACHE CREEK SERVICE AREA BY ALTERNATIVE
CACHE CREEK-SACRAMENTO RIVER DIVERSION PROJECT

(In acre-feet)

Decade	Average annual delivery		
	Irrigation (net farm delivery)	Urban	Total
1965-74	288,000	14,000	302,000
1975-84	362,000	21,000	383,000
1985-94	355,000	32,000	387,000
1995-04	344,000	47,000	391,000
2005-14	330,000	65,000	395,000

Accomplishments of the Alternative Cache Creek-Sacramento River Diversion Project, expressed as benefits accruing to project operation for irrigation and urban purposes, would aggregate some \$90,500,000 over the 50-year repayment period. These benefits are set forth in Table 55 for each purpose, by decades from 1965 through 2014. Table 55 also shows the present worth (1965) of project benefits over the 50-year repayment period, and the average annual equivalent benefits. As discussed earlier in this chapter in connection with the Wilson Valley Project, it was necessary to derive the equivalent present (1965) value of future benefits in order that they may be compared with project costs on a common-time basis.

TABLE 55

SUMMARY OF ESTIMATED BENEFITS FROM ALTERNATIVE
CACHE CREEK-SACRAMENTO RIVER DIVERSION PROJECT

(In thousands of dollars)

Decade	Average annual benefits		Present worth of	
	Irrigation	Urban	total benefits for decade	
	Irrigation	Urban	Total	Irrigation : Urban : Total
1965-74	3,554	163	3,717	29,194 1,339 30,553
1975-84	3,745	251	3,996	20,790 1,395 22,185
1985-94	4,054	394	4,448	15,175 1,476 16,651
1995-04	4,245	598	4,843	10,765 1,516 12,281
2005-14	4,294	870	5,164	7,345 1,490 8,835
Totals				83,269 7,216 90,485
Annual equivalent				3,876 336 4,212

From a comparison of annual equivalent benefits of \$4,212,000, shown in Table 53, with annual costs of the Alternative Cache Creek-Sacramento River Diversion Project (\$1,859,000), the indicated benefit-cost ratio is 2.27 to 1. This demonstrates a relatively high degree of economic justification. However, this project could not provide the benefits that would accrue from comprehensive development of the water resources of the Clear Lake-Cache Creek Basin. The waters of Cache Creek would not be effectively utilized under the alternative project, while, at the same time, waters developed elsewhere would be imported into the watershed. Moreover, no provision would be made for development of additional water supplies for areas tributary to Clear Lake, and only limited flood control and recreation enhancement would be achieved.

Alternative Clear Lake Flood Control Project

Enlargement of the Clear Lake outlet channel to provide flood protection for the Clear Lake shore line was discussed earlier in this chapter as a feature of the Wilson Valley Project. As stated, enlargement of the channel would require modification of both the Gopcevic and Bemmerly Decrees which presently prohibit deepening and widening of the channel. Construction and operation of Wilson Valley Dam and Reservoir would remove the objections on which the decrees were founded.

Operation studies with an enlarged Clear Lake outlet channel, but without Wilson Valley Reservoir, were made to evaluate effects of the enlarged channel on flood discharges in the lower reaches of Cache Creek. The floods of 1956 and 1958 were routed



Clear Lake
Outlet Channel

ABOVE:
Looking upstream
towards Grigsby
Rifle from old
highway bridge

RIGHT:
Looking downstream
towards "Narrows" from
old highway bridge



through the outlet channel enlarged to a capacity of 8,500 second-feet at a reading of 7.56 on the Rumsey Gage.

Hydrographs showing historical and controlled flood conditions for the floods of February and March, 1958 are depicted on Plate 19, "Flood Operation of Clear Lake and Cache Creek Without Wilson Valley Reservoir". During this flood the lake level exceeded an elevation of 9.0 feet on the Rumsey Gage for a continuous period of 44 days, and reached a peak stage of 10.9 feet. The discharge of Cache Creek at Rumsey during this flood reached a maximum rate of about 52,000 second-feet. The hydrograph of historical discharge, shown on Plate 19, illustrates that this flood, typical of most floods in Cache Creek, rose and fell very sharply within a period of less than 24 hours.

Operation of the Alternative Clear Lake Flood Control Project without Wilson Valley Reservoir was predicated upon the timing of releases of water from Clear Lake so that such releases would pass through the lower reaches of Cache Creek before and after, but not during, the main flood peak from runoff of the watershed below Clear Lake. For this study, it was assumed that Clear Lake would be held at a stage of 7.56 feet by controlling releases during flood stages of Cache Creek, as indicated by the flood warning gage at Rumsey. Flood stages could be anticipated a few hours in advance by means of automatic recording rain gages at strategic locations in the watershed.

The gates of the Clear Lake Impounding Dam would be closed during flood stages of Cache Creek, and would remain closed until eight hours after the peak flow at Rumsey had passed. This delay would allow the flood peak to reach the Yolo Bypass.

Following this, releases from Clear Lake would again commence, to reduce the stage to 7.56 feet on the Rumsey Gage as soon as possible. Results of a routing of the 1958 flood, plotted on Plate 19, show that the maximum water surface elevation in Clear Lake could have been reduced to 8.4 feet, rather than the 10.9 feet actually experienced. Furthermore, by withholding the discharge from Clear Lake, the peak flood discharge at Rumsey would have been reduced from 52,000 second-feet to about 45,000 second-feet.

As described under discussion of the Wilson Valley Project, the capital cost of enlarging the Clear Lake outlet channel was estimated to be about \$1,250,000. Corresponding annual costs, at an interest rate of four percent per annum, were estimated to be about \$68,000. The average annual flood control benefits that would accrue to the shore line of Clear Lake from operation of the Wilson Valley Project were estimated to be \$345,000. It was estimated that a considerable portion of these benefits could be gained by operation of the alternative flood control project without Wilson Valley Reservoir. The indicated benefit-cost ratio of the Alternative Clear Lake Flood Control Project would be in excess of 4 to 1.

Summary Comparison of Wilson Valley Project and Alternatives

In order that a project be an alternative to another project in the full sense of the word, it should provide equal service to the same project service area. With this definition in mind, it is clear that neither the Alternative Cache Creek-Sacramento River Diversion Project nor the Alternative Clear Lake

Flood Control Project are true alternatives to the Wilson Valley Project. Rather, they are only partial alternatives for certain project purposes.

The Alternative Cache Creek-Sacramento River Diversion Project would deliver sufficient water to meet the potential ultimate water requirement in the Cache Creek Service Area. However, it would not make water available for use in the Clear Lake Basin, except by an exchange arrangement. Such an arrangement would be disadvantageous to users in the Cache Creek Service Area, as it would involve the substitution of more expensive imported water for surface supplies from Cache Creek. On the other hand, the Wilson Valley Project would make a firm annual water supply of 36,000 acre-feet available for development within the Clear Lake Basin. At the same time, the project would come within 15,000 acre-feet per year of meeting the potential ultimate (2015) water requirement in the Cache Creek Service Area.

While the Alternative Cache Creek-Sacramento River Diversion Project could accomplish some flood control, such control would be limited to the lower Cache Creek area and would be only nominal. Indian Valley Reservoir would provide regulation for only the North Fork of Cache Creek. An enlarged Clear Lake outlet channel could be operated in conjunction with Indian Valley Reservoir to provide flood protection around Clear Lake. However, the efficiency of operation of Clear Lake would be impaired because of the absence of downstream control on the main stem of Cache Creek. Moreover, necessary modification of the Bemmerly and Gopcevic Decrees might prove difficult, because of the lack of downstream control.

In order to achieve maximum flood control benefits in the Clear Lake-Cache Creek Basin, the enlarged Clear Lake outlet channel should be operated in conjunction with Wilson Valley Reservoir. Such operation would permit sustained flood releases from Clear Lake and concurrent reduction of peak discharge rates in the lower reaches of Cache Creek. Moreover, with the positive control of Cache Creek runoff at the Wilson Valley site, the Gopcevic and Bemmerly Decrees could be modified or set aside, with reasonable assurance that conditions which those decrees were designed to prevent would no longer be a problem.

The opportunity for recreation use at Indian Valley Reservoir would be much more restricted than at the Wilson Valley Reservoir. There would be no recreation enhancement around Clear Lake with the Alternative Cache Creek-Sacramento River Diversion Project. However, recreation at Brooks Reservoir and along lower Cache Creek would be essentially the same with either project.

In summary, the Wilson Valley Project would create greater net benefits, both local and statewide, than would the Alternative Cache Creek-Sacramento River Diversion Project. Moreover, the Wilson Valley Project would effect the most efficient development of California's water resources by meeting local water needs with locally developed water resources, thereby permitting water which otherwise would have to be imported to the area, to be used in meeting the commitments of the State Water Facilities which will be constructed and operated under provisions of the California Water Resources Development Bond Act. Perhaps most significant, however, is the fact that the Wilson Valley Project would enhance the economy of both Lake and Yolo Counties, and

provide the incentive for joint participation by both counties in financing, construction, and operation of the project.

CHAPTER V. SUMMARY OF CONCLUSIONS AND RECOMMENDATIONS

As a result of field investigation and analysis of available data on water resources and water problems of the Clear Lake-Cache Creek Basin, and on the basis of the estimates and assumptions discussed in this bulletin, the following conclusions and recommendations are made.

Conclusions

1. Present water problems in the Clear Lake-Cache Creek Basin concern both water supply and flood control. The most significant problems consist of:

- a. Seasonal uncertainty in the availability of surface water supplies in the Cache Creek Service Area, which restricts the planting of certain agricultural crops, resulting in impairment of the agricultural economy;
- b. Ground water overdraft in the Cache Creek Service Area, with resultant increase in costs of agricultural production;
- c. Limitation on further development of the water resources of the Clear Lake Basin under present water rights held by downstream users; and
- d. Periodic occurrence of heavy winter and spring storms with resultant flood flows that cause damage to lands around Clear Lake and along the lower portion of Cache Creek.

2. Essentially all the present water requirement of 37,000 acre-feet per year in the Clear Lake Basin is met by pumping from underlying ground water storage without incurring a ground water overdraft. However, seasonal fluctuation in ground water levels has resulted in inconvenience or expense of deepening of wells or lowering of pumps in certain areas.

3. The potential ultimate mean annual requirement for supplemental water in the Clear Lake Basin is estimated to be 165,000 acre-feet on a farm delivery basis, distributed as follows: Big Valley, 22,000 acre-feet; Scott Valley, 2,500 acre-feet; Upper Lake, 13,000 acre-feet; and remaining area, 128,000 acre-feet.

4. The present mean annual water requirement in the Cache Creek Service Area amounts to 287,000 acre-feet on a farm delivery basis, of which an estimated 72,000 acre-feet is developed from surface sources and about 160,000 acre-feet is developed from pumping from underlying ground water storage. The present supplemental water requirement, represented by the difference between the present water requirement (287,000 acre-feet) and the safe yield of surface and ground water supplies (232,000 acre-feet), amounts to about 55,000 acre-feet per year.

5. The potential annual ultimate (2015) supplemental water requirement in the Cache Creek Service Area is forecast to be 163,000 acre-feet.

6. Except for the presence of boron, the waters of the Cache Creek Basin are of satisfactory mineral quality for agricultural uses. However, concentrations of boron in the surface

water supplies and in certain of the ground water supplies preclude the use of those supplies for irrigation of crops which are extremely sensitive to boron.

7. A source of supplemental water is available locally in runoff from Cache Creek and its tributaries that presently wastes from the Clear Lake-Cache Creek Basin. This waste, which averaged about 340,000 acre-feet per year during the mean period, occurs in a widely varying pattern from year to year, ranging from a low of 3,000 acre-feet in 1919-20 to a maximum of 1,400,000 acre-feet in 1940-41. Because of this extreme seasonal and cyclic variation, it would be neither physically nor economically feasible to develop such waste water to the extent necessary to meet potential ultimate water requirements within the basin.

8. The Wilson Valley Project, involving the coordinated operation of 1,000,000 acre-feet of storage at the Wilson Valley site on Cache Creek, 314,000 acre-feet in Clear Lake, enlargement of the Clear Lake outlet channel, a downstream regulatory reservoir at the Brooks site on Cache Creek, and acquisition and enlargement of the existing distribution system of the Clear Lake Water Company, could make sufficient water available in the Cache Creek Service Area and in Clear Lake to meet increasing water requirements in both Yolo and Lake Counties for a considerable number of years into the future. Moreover, the project would provide substantial flood control and recreational benefits for both counties.

9. The Wilson Valley Project would increase the firm water supply in the Cache Creek Service Area by 148,000 acre-feet per year, distributed as follows: surface water supplies, 105,000 acre-feet; increased ground water replenishment, 43,000 acre-feet. By operation of Wilson Valley Reservoir in conjunction with Clear Lake, an additional 36,000 acre-feet per year could be made available to the Clear Lake Basin on a farm delivery basis. Development and use of this water would result in a net depletion of inflow into the Wilson Valley Reservoir of 21,000 acre-feet per year.

10. Operation of the Wilson Valley Project would substantially reduce flood damages by:

a. Limiting the water level in Clear Lake to an elevation of 9 feet on the Rumsey Gage at Lakeport by enlargement of the Clear Lake outlet channel, thus providing protection to lands and developments on the perimeter of the lake;

b. Reduction of peak flood flows in the lower Cache Creek channel, by detention in Wilson Valley Reservoir, thereby protecting lands along the lower reaches of the channel from inundation;

c. Controlling discharges in lower Cache Creek channel to 21,000 second-feet at all times except during extreme floods, thereby reducing erosion damage along Cache Creek; and

d. Extention of the life of the Cache Creek settling basin by reduction of silt accumulation therein.

11. The Wilson Valley Project would substantially enhance recreational opportunities both around Clear Lake and around the Wilson Valley Reservoir, as well as maintaining year round stream flow, thus improving the sport fishery of Cache Creek.

12. The capital and annual costs of the Wilson Valley Project are estimated to be \$45,010,000 and \$2,942,000, respectively. These costs are broken down among the several component features of the project as follows:

	<u>Capital cost</u>	<u>Annual cost</u>
Wilson Valley Dam and Reservoir	\$ 34,515,000	\$ 1,819,000
Clear Lake outlet channel enlargement	1,250,000	68,000
Brooks Dam and Reservoir	1,819,000	98,000
Distribution System	4,746,000	529,000
Onshore Recreation Facilities (at Wilson Valley and Clear Lake)	2,680,000	428,000

13. The Wilson Valley Project could be staged to a minor extent by deferring construction of Brooks Dam and Reservoir and portions of the distribution system. Wilson Valley Dam could not be staged because of the high spillway costs. The cost of the initial project features would be \$41,484,000.

14. The estimated capital cost of the Wilson Valley Project includes \$8,229,000 for relocation of State Highway 20. This relocation cost includes \$1,735,000 estimated by the State Division of Highways as the amount creditable for betterment of the relocated road to expressway standards.

15. The Wilson Valley Project would create estimated total benefits over the project repayment period amounting to \$144,000,000 on a present worth basis. Corresponding annual

equivalent benefits would be \$6,712,000 as shown in the following tabulation:

Irrigation (Cache Creek Service Area)	\$3,718,000
Municipal and industrial (urban)	336,000
Recreation	2,128,000
Flood control	530,000

16. Economic justification of the Wilson Valley Project is indicated by a benefit-cost ratio of 2.33 to 1.

17. Costs of the Wilson Valley Project were allocated in accordance with the separable cost-remaining benefits method as follows:

Irrigation	\$25,335,000
Municipal and industrial (urban)	3,984,000
Recreation	10,016,000
Flood control	5,675,000

18. Based upon the foregoing cost allocation, the following assumptions were made with respect to nonreimbursable contributions to the Wilson Valley Project.

a. That the Federal Government, through the U. S. Corps of Engineers, would contribute \$5,675,000 in the interest of flood control;

b. That the State, through the California Highway Commission, would contribute \$1,735,000 for improvement of the relocated State Highway 20 to expressway standards; and

c. That the Legislature, under provisions of Section 12880 of the Water Code, would grant \$7,336,000 in the interest of recreation as a

statewide benefit. This value represents the allocation to recreation (\$10,016,000) minus the cost of locally financed onshore recreation facilities (\$2,680,000).

19. Assuming nonreimbursable contributions to the Wilson Valley Project in accordance with the foregoing conclusion, the reimbursable costs to be borne by the local agency would be \$26,648,000. The resultant cost per acre-foot for irrigation and urban water would be about \$8 and \$19, respectively. Assuming no State recreation grant and elimination of the onshore recreation facilities, the local agency reimbursable cost per acre-foot for irrigation and urban water would be about \$9 and \$22, respectively. It should be pointed out that these costs do not reflect the value of the 36,000 acre-feet of water reserved in Clear Lake for use within the Clear Lake Basin. To the extent that Lake County would participate in the project to assure the availability of this water, the cost of water in the Cache Creek Service Area would be reduced.

20. The payment capacity for irrigation and urban water in the Cache Creek Service Area, estimated to be \$12.50 and \$34 per acre-foot, respectively, substantially exceeds the indicated costs of water set forth in the preceding conclusion, either with or without a nonreimbursable State recreation grant.

21. The Alternative Cache Creek-Sacramento River Diversion Project is a possible alternative to the Wilson Valley Project with respect to provision of supplemental water to the Cache Creek Service Area. However, it would not improve the operation of Clear Lake, and would not make additional water

available for the Clear Lake Basin. Moreover, the project would provide only limited flood control in the lower Cache Creek area and would not provide flood control around Clear Lake. Similarly, the project would provide only nominal recreational opportunities around the Indian Valley Reservoir and none around Clear Lake.

22. The capital and annual costs of the Alternative Cache Creek-Sacramento River Diversion Project are estimated to be \$17,498,000 and \$1,859,000, respectively. These costs are broken down among the several component features of the project as follows:

	<u>Capital cost</u>	<u>Annual cost</u>
Indian Valley Dam and Reservoir	\$3,976,000	\$219,000
Brooks Dam and Reservoir	1,819,000	98,000
Distribution System	4,746,000	529,000
Sacramento River Diversion	6,957,000	663,000
Delta Water Charge		350,000

23. The Alternative Cache Creek-Sacramento River Diversion Project would create estimated irrigation and urban benefits over the project repayment period amounting to \$90,485,000 on a present worth basis. Corresponding annual equivalent benefits would be \$4,212,000. Although the Indian Valley Reservoir would create nominal flood control and recreation benefits, such benefits were not evaluated. However, the nonreimbursable grants for those purposes probably would not offset the added costs of facilities required to create the additional benefits.

24. Economic justification of the Alternative Cache Creek-Sacramento River Diversion Project, based upon irrigation and urban benefits, and including a charge of \$3.50 per acre-foot for water diverted from the Sacramento River, is indicated by a benefit-cost ratio of 2.27 to 1.

25. Assuming that project costs would be repayed by the sale of irrigation and urban water, the indicated cost of water under the Alternative Cache Creek-Sacramento River Diversion Project would be about \$8 per acre-foot.

26. The Alternative Cache Creek-Sacramento River Diversion Project would be susceptible of staged construction, with initial construction of Indian Valley Dam and Reservoir. Construction of the Sacramento River Diversion, Brooks Dam and Reservoir, and enlargement and extension of the distribution system could be scheduled to meet the increasing demand for project water.

27. The Alternative Clear Lake Flood Control Project would reduce flooding around Clear Lake by enabling greater releases of flood water, thereby providing closer control of lake levels. However, it would provide only nominal improvement of present flood conditions along lower Cache Creek. While the benefit-cost ratio of the alternative would be in excess of 4 to 1 as a separate project, greater benefits could be realized from an enlarged outlet channel as a feature of a comprehensive multipurpose project.

28. After study and evaluation of possible plans for water development, the Wilson Valley Project was selected as the best plan for development of the water resources of the Clear Lake-Cache Creek Basin. Moreover, the project is superior to alternative plans involving a combination of partial development of local water resources and importation of water from the Sacramento River. In relation to such alternatives, the Wilson Valley Project:

a. Conforms to the philosophy expressed in Bulletin No. 3, "The California Water Plan", by making optimum use of local water resources;

b. Would create maximum net benefits to the local economy in both Lake and Yolo Counties through water conservation, flood control, and recreation accomplishments;

c. Would permit water which otherwise would have to be imported to the Cache Creek Service Area, to be used in meeting the commitments of the State Water Facilities which will be constructed and operated under provisions of the California Water Resources Development Bond Act; and

d. Would deliver and distribute water in the Cache Creek Service Area at an equivalent annual unit cost and, furthermore, would make additional water available in Clear Lake for use within the Clear Lake Basin.

29. The Cache Creek Service Area is extensively developed and can readily absorb additional water with nominal enlargement and extension of the existing distribution system which serves most of the area.

30. The Yolo County Flood Control and Conservation District has expressed keen interest in the Wilson Valley Project and has the legal authority to construct and operate the project.

31. Based on an estimated assessed valuation of \$90,000,000 and on existing overlapping bonded indebtedness, it

appears that a maximum practical bonding capacity for general obligation bonds of the Yolo County Flood Control and Conservation District would be about \$20,000,000.

32. The Wilson Valley Project is financially feasible, provided that local interests can secure supplemental financing on a loan basis to meet the portion of the reimbursable project costs in excess of local financing capability.

Recommendations

It is recommended:

1. That, for the following reasons, the Wilson Valley Project be adopted as the plan for development of supplemental water for lands within the Clear Lake-Cache Creek Basin:

a. The project, in conformance with The California Water Plan, would effect full economical development of the water resources of Cache Creek;

b. The project would be a multipurpose development, providing conservation, flood control, and recreation for both Lake and Yolo Counties; and

c. In relation to possible alternatives, the project would return the maximum net benefits to the economy of both the basin and the State.

2. That local interests consider the necessary steps to initiate construction of the Wilson Valley Project. These steps should include:

a. A firm determination of local financing capacity;

b. A determination of probable federal non-reimbursable contribution to the project in the interests of flood control;

c. Evaluation of additional funds required to fully finance the project; and

d. Initiation of action to modify the Bemmerly Decree to permit enlargement of the Clear Lake outlet channel, and modification of the Gopcevic Decree to permit the operation of Clear Lake as a feature of the Wilson Valley Project.

3. That interests in Lake County consider participation jointly with interests in Yolo County in financing the Wilson Valley Project, in accordance with the yield and other benefits that would accrue to Lake County, such participation to be achieved in a manner to be negotiated by the two counties.

4. That local interests request the U. S. Corps of Engineers:

a. To make a survey of the flood control benefits accruing to the Wilson Valley Project and to determine the recommended federal non-reimbursable contribution in the interest of flood control; and

b. To request congressional approval and appropriation of funds for such contribution. (This is preliminarily estimated at 5.7 million dollars.)

5. That local interests request consideration of contribution by the State (California Highway Commission) of necessary funds for construction of Highway 20 to expressway standards, over and above the cost of replacement-in-kind. This has been preliminarily estimated to be \$1,735,000.

6. That local interests explore possible sources of financial assistance in construction of the Wilson Valley Project. These sources consist of:

a. Federal financial assistance through a loan or through federal construction of the project; and

b. State financial assistance in the form of a grant and loan by the Legislature under provisions of the Davis-Grunsky Act (Section 12880 of the Water Code).

7. That, in the event that local interests are unsuccessful in securing financial assistance in the Wilson Valley Project consideration be given to the Alternative Cache Creek-Sacramento River Diversion Project.



A P P E N D I X A

IN THE SUPERIOR COURT OF THE STATE OF CALIFORNIA,
IN AND FOR THE COUNTY OF MENDOCINO

M.M. GOPCEVIC, and THE HOTALING
ESTATE CO., a corporation, and
GEORGE T. RUDDICK,

Plaintiffs,

vs.

YOLO WATER AND POWER COMPANY,
a corporation, and YOLO WATER AND
POWER CORPORATION, a corporation,

Defendants,

COUNTY OF LAKE

and LISLE STUBBS, et al,

Intervenor

DECREE

Pursuant to the stipulation of all parties herein reduced to writing and filed in open court on the 7th day of October, 1920, agreeing and consenting that the following judgment and decree be entered in the above entitled action, and upon evidence taken; and finding being waived in open court by all parties;

IT IS HEREBY ORDERED ADJUDGED AND DECREED AS FOLLOWS:

That the defendant herein be perpetually enjoined and restrained from excavating or deepening the outlet of Clear Lake, being the Clear Lake mentioned in the pleadings herein, to any depth greater than four feet below the zero mark on the Rumsey

Gauge at Lakeport, County of Lake, State of California, which said gauge is hereinafter more particularly referred to; and from widening straightening or otherwise interfering with said outlet, except as may be necessary to carry out the provisions of this decree, all of such work to be with the approval first obtained and under the supervision of the State Railroad Commission of California, or the members thereof; and this injunction shall include the said defendants, their and either of their, officers, agents, servants, employees successors and assigns, and each and all officers and agents of either of them, and all persons acting under or in aid of them or either of them.

That the agents, servants, employees, successors and assigns of the said defendants and the said defendants and each of them, and all persons acting under or in aid of them or either of them be perpetually enjoined and restrained from at any time, or in any way raising the level of said lake in excess of 7.56 feet above zero on said Rumsey Gauge, and from at any time or at any way lowering the level of said lake below zero on said Rumsey Gauge; provided, however, that the rise of said Clear Lake, by reason of storm or flood conditions beyond the control of said defendants, or either of them, to a level in excess of 7.56 feet above zero on said Rumsey Gauge, but in no event to a level in excess of 9.00 feet above zero on said Rumsey Gauge, for any period not exceeding ten successive days, shall not be deemed a violation hereof;

The zero mark on said Rumsey Gauge is 20.1 feet below center of large concrete star in northeast corner of court house yard at said Lakeport, and 21.56 feet below iron step at front entrance to Bank of Lake Building at southeast corner of Main Street and Second Street, in said Lakeport;

That said defendants, and each of the, their officers, agents, employees, successors and assigns and all persons acting under or in aid of them or either of them, be perpetually enjoined and restrained from drawing off from said Clear Lake an amount of water which, inclusive of evaporation and other losses, will at any time reduce the level of said lake below zero on said Rumsey Gauge, and the said defendants, and each of them, their officers, agents, employees, successors and assigns, be perpetually enjoined and commanded to draw off from said lake an amount of water which, inclusive of evaporation and other losses will reduce the level of the lake so that the elevation thereof on the following dates shall not exceed the following percentages of the actual level on April 15th of each year;

May 1, 97%, June 1, 89%, July 1, 79%, August 1, 69% and September 1, 58%.

That said defendants and each of them, their officers, agents, employees, successors and assigns, be perpetually enjoined and restrained from drawing off from said lake, during the

irrigation season an amount of water which, inclusive of evaporation and other losses shall lower the level of said lake more than two feet in any one month;

It is hereby specially adjudged and decreed that notwithstanding the limits of depression of said lake waters hereinabove described the said defendants, and each of them, their agents, employees, successors and assigns, shall not draw off or allow, and they and each of them are enjoined and restrained from drawing off or allowing the waters of said lake to flow out of said lake at any time at such a rate as that, taking into account evaporation and other losses, the water of said lake shall at the lowest level of any year be below zero on said Rumsey Gauge;

It is further adjudged and decreed that the said defendants, or either of them, shall at or about the specific dates last hereinabove mentioned, notify in writing, through the mails or otherwise, the parties hereto and as well such owners or occupants of land on the rim of said lake as shall register their names and addresses with the defendant, Yolo Water and Power Company, at its office in Woodland, Yolo County, California, of the then existing and respective levels of the said lake.

The drawing off of the water of said lake under the conditions aforesaid, shall be by and through the dam and gates mentioned in the pleadings herein, and the administration conduct and operation of said dam and gates shall be responsive to and in full and fair execution of such conditions, and shall at

all times be by and under the State Railroad Commission of California, or the members thereof;

If at any time the injunctive provisions of this decree shall be violated, or departed from in matter of substance and all the provisions of this decree are for this purpose taken to be injunctive then and in such events the said defendants and each of them are hereby enjoined and commanded forthwith thereupon, in the manner and to the extent hereinafter provided, or in default thereof it shall be competent to the plaintiffs or any or either of them, or in default of action in the promises by the plaintiffs or any or either of them, it shall be competent to the interveners, or any or either of them, and said parties are accordingly hereby authorized, at the expense of defendants, their successors and assigns to restore and maintain at the "Grigsby Riffle" mentioned in the complaint herein, but above the present mouth of "Seigler Creek" a suitable and substantial structure or barrier, the crest of which shall not exceed one foot above zero on said Rumsey Gauge except as hereinafter provided;

But it is further and specifically decreed that if at any time, for any physical reason, or otherwise, said dam should cease in any substantial sense, to function in respect to the operation of the same as hereinabove referred to, then and in that event the crest of the aforesaid structure or barrier may be increased and maintained to an elevation of two feet above zero on said Rumsey Gauge, said structure and barrier shall exist

and be maintained at all times when a dam shall cease to function as provided in this decree for the operation of the same; provided however that the failure of the defendants or either of them to comply substantially with the terms of this decree, due to temporary, unavoidable causes shall not be deemed a violation of this decree;

It is further adjudged that this decree does not adjudicate upon the extent of the several riparian or littoral rights of any of the parties hereto in the said Clear Lake or the land adjacent thereto nor upon any rights or claims of any of said parties to water rights therein, nor in or over such adjacent lands, and that the injunctive relief hereby granted and provided for is not based upon a waiver by any of said parties of any such substantive rights of claims aforementioned but is subject to full reservations on the part of all and each of said parties of all said substantive rights or claims aforesaid;

It is further ordered adjudged and decreed that the said dam and the operation thereof shall at all times be subject to reasonable access and inspection by the parties hereto as well as any person owning land riparian or littoral to said Clear Lake and their duly authorized agents or attorneys; but if any question should arise in respect to the right of any such person or persons to such access and inspection, the same shall be remitted to the State Railroad Commission of California, or the members thereof for final determination.

That all claims for damages involved in this action or on account of the issuance of the temporary restraining order or preliminary injunction herein are waived and adjudged to be fully settled;

That each party to this action shall pay his own costs.

The signing and filing of this decree shall be deemed to be noticed of the terms thereof and effective as service of any injunctive process consequent thereon.

Done in open Court the 7th day of October, 1920.

A. B. McKENZIE
Judge.

CERTIFIED: October 7th, 1920, by the Clerk of said Court to be a full, true and correct copy of the original on file and of record in his office.

ENDORSED: Filed October 7, 1920, HALE PRATHER, Clerk
by W. H. PRATHER, Deputy

RECORDED: October 8th, 1920, in vol. 60 of Deeds, at page 49.
Records of Lake County, California.

C.C. McDONALD,
Attorney for Plaintiffs,
Woodland, California.

IN THE SUPERIOR COURT OF THE STATE OF CALIFORNIA,
IN AND FOR THE COUNTY OF YOLO

MARY E. BEMMERLY and AGNES H. BEMMERLY,
Plaintiffs,

vs.

THE COUNTY OF LAKE, a Political Subdivision
of the State of California, E. L. HERRICK,
W. E. REICHERT, L. D. KIRKPATRICK, L. L. BURGER
and J. S. KELSAY, as and comprising the Board
of Supervisors of the County of Lake, State of
California, THE BOARD OF SUPERVISORS OF THE COUNTY
OF LAKE, STATE OF CALIFORNIA, E. L. HERRICK,
individually and as a member of the Board of
Supervisors of the County of Lake, State of
California, FRANK W. NOEL, individually,
W. E. REICHERT, as a member of the Board of
Supervisors of the County of Lake, State of
California, W. T. SMITH, individually,
L. D. KIRKPATRICK, as a member of the Board
of Supervisors of the County of Lake, State
of California, L. L. BURGER, individually
and as a member of the Board of Supervisors
of the County of Lake, State of California,
J. S. KELSAY, individually and as a member
of the Board of Supervisors of the County of
Lake, State of California, FRANK B. JOHNSON,
individually and as a County Surveyor of
the County of Lake, State of California,
FRANK W. CLARK as Director of the Department
of Public Works of the State of California,
CLEAR LAKE WATER COMPANY, A CORPORATION,
J. R. REEVES, JOHN DOE DREDGING COMPANY,
RICHARD DOE DREDGING COMPANY, FIRST DOE,
SECOND ROE AND THIRD ROE,

Defendants.

No. 8812

J U D G M E N T

This cause having been regularly called and tried by the Court, and the findings of fact and conclusions of law, and the decision thereon in writing, having been rendered, wherein judgment was ordered in favor of the plaintiffs and against the defendants hereinafter named as prayed for in the complaint and for costs,

IT IS, BY THE COURT, ORDERED, ADJUDGED AND DECREED that the defendants, The County of Lake, a Political Subdivision of the State of California, E. L. Herrick, W. E. Reichert, L. D. Kirkpatrick, L. L. Burger and J. S. Kelsay, as and comprising the Board of Supervisors of the County of Lake, State of California, the Board of Supervisors of the County of Lake, State of California, E. L. Herrick, individually and as a member of the Board of Supervisors of the County of Lake, State of California, Frank W. Noel, individually, W. E. Reichert as a member of the Board of Supervisors of the County of Lake, State of California, W. T. Smith, individually, L. D. Kirkpatrick as a member of the Board of Supervisors of the County of Lake, State of California, L. L. Burger, individually and as a member of the Board of Supervisors of the County of Lake, State of California, J. S. Kelsay, individually and as a member of the Board of Supervisors of the County of Lake, State of California, Frank B. Johnson, individually and as County Surveyor of the County of Lake, State of California, Frank W. Clark, as Director of the Department of Public Works of the State of California,

and Clear Lake Water Company, a corporation, and each and all of them, and their, and each of their attorneys, agents, servants and employees and any and all persons acting under said defendants, or any of them, be, and they and each and all of them are hereby forever enjoined and restrained from in any manner widening, deepening, or enlarging the arm or slough which constitutes the outlet of the waters of and from Clear Lake into Cache Creek and from in any manner changing the said outlet so as to increase the flow of waters of and from Clear Lake into Cache Creek. The Clear Lake herein referred to is the Clear Lake described in the plaintiffs' complaint and which is located in the County of Lake, State of California.

IT IS FURTHER ORDERED, ADJUDGED AND DECREED that plaintiffs have judgment for their costs taxed at Dollars (\$)

Judgment rendered December 18, 1940.

Dal M. Lemmon
Judge of the Superior Court.

AGREEMENT FOR SETTLEMENT
OF WATER RIGHTS DISPUTE

THIS AGREEMENT, made this 17th day of May, 1960 between Lake County and the Lake County Flood Control and Water Conservation District, on the one hand, hereinafter collectively called "Lake County", and Yolo County and the Yolo County Flood Control and Water Conservation District, on the other hand, hereinafter collectively called "Yolo County".

W I T N E S S E T H:

WHEREAS, Yolo County has filed Applications No. 15975, 15976 and 15977 with the State Water Rights Board for the appropriation of unappropriated water of the Cache Creek watershed; and

WHEREAS, Lake County plans to construct certain reservoirs in the same watershed, and has protested the applications of Yolo County; and

WHEREAS, in executing this agreement, Lake County understands that, as against the developments under said applications of Yolo County, Lake County will be limited in developing the Cache Creek watershed to the maximum amounts of storage specified in paragraphs (a), (b), and (c) of Article 2 below, and is willing to accept this limitation in order to accomplish full development of the watershed, with the widest benefits possible; and

WHEREAS, Yolo County, in turn, is informed that storage of water for use in Lake County, as specified in paragraphs (a), (b), and (c) of Article 2 below, will reduce the yield of Projects

constructed under said Applications Nos. 15975, 15976, and 15977 and is willing to accept this reduction in yield in order to accomplish full development of the watershed, with the widest benefits possible.

WHEREFORE, in accordance with the foregoing, Lake County and Yolo County hereby agree as follows:

1. Lake County agrees and consents to the approval of and issuance of a permit or permits by the State Water Rights Board under Applications 15975, 15976 and 15977 held by Yolo County, provided that such permit or permits be issued subject to depletions of stream flow by future appropriations of water for use in Lake County as set forth below in Article 2. Lake County will join Yolo County in requesting the State Water Rights Board to issue such permit or permits subject to such depletions, and Lake County will dismiss its protests to Applications Nos. 15975, 15976 and 15977.

2. Yolo County agrees that it will not protest any applications to appropriate unappropriated water in the amounts stated in paragraphs (a), (b), and (c) of this Article, which applications may be filed after the execution of this agreement by any applicant for use in Lake County within the Cache Creek watershed, provided that such applications shall have been first approved by the Board of Supervisors of Lake County or its designee, and that it will withdraw its protest to Application No. 15667 for storage of the waters of Highland Creek. Lake and Yolo Counties agree that any such applications shall be deemed to have

equal priority in right with Application No. 15975, 15976 and 15977, so that in years of shortage the water supply available under all such applications for use in Lake and Yolo Counties shall be prorated among the applicants thereof on the basis of the maximum amount of water allowed to be stored annually under the permit (or license, if license has been issued) granted under each of such applications, provided that in any such year the applicants having permits or licenses for use in Lake County shall together be entitled to not less than forty percent of the water supply available under all such applications for use in Lake and Yolo Counties of waters of Cache Creek upstream from the Clear Lake Dam, including Clear Lake and its tributaries, provided further that the entitlements under said proration shall always be subject to the requisite of beneficial use and to the availability of water for appropriation under the specific application involved. The applications for use in Lake County may be filed for:

(a) Storage of up to a total of 75,000 acre-feet of water annually in the proposed Kelseyville Reservoir, Lakeport Reservoir, and Pitney Ridge Reservoir, which proposed reservoirs are more particularly described in the Department of Water Resources' Bulletin 14, entitled "Lake County Investigation," dated July 1957, or in equivalent sites in Big Valley, Scott Valley or Upper Lake areas, provided that said total of 75,000 acre-feet shall be reduced by the maximum amount of water allowed to be stored annually pursuant to any rights which may be perfected under Application No. 12389 for the storage of the waters of Kelsey Creek;

(b) Storage of up to a total of 10,000 acre-feet of water annually in the proposed Excelsior Reservoir, Seigler Creek, Burns Valley or in an equivalent site or sites suitable to the need of Lake County in this area;

(c) Storage of up to a total of 5,000 acre-feet of water annually in small reservoirs for use in Lake County, other than those described in (a) and (b) above.

3. This agreement shall become effective upon its execution by the Boards of Supervisors of Lake and Yolo Counties and issuance of permits by the State Water Rights Board under Application 15975 subject to conditions substantially in conformity with this agreement. It will be terminated if Application No. 15975 is rejected or cancelled by the State Water Rights Board.

4. This agreement does not affect the priority of Application No. 12389 for the storage of the waters of Kelsey Creek or of Application No. 11389 for the storage of the waters of the North Fork of Cache Creek as those priorities would exist in the absence of this agreement.

5. The successors and assigns of the parties shall be bound by the obligations of this agreement and shall be entitled to receive its benefits.

COUNTY OF YOLO

ATTEST: Charles S. Payton
Clerk of the Board of
Supervisors

By /s/ Pete E. Lucas
Deputy

By /s/ L. D. Drew
Chairman of the Board of
Supervisors

YOLO COUNTY FLOOD CONTROL AND
WATER CONSERVATION DISTRICT

By/s/ J. Bernell Harlan
Chairman of the Board of
Directors

COUNTY OF LAKE

ATTEST: Charlton R. Phillips
Clerk of the Board of
Supervisors

By /s/ Teresa G. Rifesi
Deputy County Clerk

By/s/ Earle W. Wrieden
Chairman of the Board of
Supervisors

LAKE COUNTY FLOOD CONTROL
AND WATER CONSERVATION
DISTRICT

By/s/ Earle W. Wrieden
Chairman, Board of Directors

STANLEY MOSK, Attorney General
of the State of California
JAMES M. SANDERSON, Deputy Attorney General
LLOYD HINKELMAN, Deputy Attorney General
Library and Courts Building
Sacramento 14, California
Telephone: Hickory 5-4711, Extension 3969

Attorneys for Protestant, CALIFORNIA
DEPARTMENT OF FISH AND GAME.

BEFORE THE STATE WATER
RIGHTS BOARD OF THE STATE OF
CALIFORNIA

In the Matter of Applications Nos. 11389, 15975, 15976 and 15977,	}	SOURCE: CACHE AND NORTH FORK CACHE CREEKS
COUNTY OF YOLO, Applicant,		COUNTIES: LAKE, COLUSA AND YOLO
CALIFORNIA DEPARTMENT OF FISH AND GAME, et al., Protestants.)	}	<u>STIPULATION AND AGREEMENT</u>

IT IS HEREBY STIPULATED AND AGREED by and between the
Applicant, COUNTY OF YOLO, its successors and assigns, and the
Protestant, the STATE OF CALIFORNIA, ACTING BY AND THROUGH ITS
DEPARTMENT OF FISH AND GAME, as follows:

WHEREAS, the State Water Rights Board has before it
Water Rights Applications Nos. 11389, 15975, 15976, and 15977
of the COUNTY OF YOLO; and

WHEREAS, the parties have negotiated a settlement of
the protest of said Protestant CALIFORNIA DEPARTMENT OF FISH
AND GAME against said applications;

NOW, THEREFORE, the parties hereby agree to request the State Water Rights Board by this Stipulation and Agreement, to insert terms and conditions in any and all permits issued pursuant to said applications, and said Applicant agrees, (1) that upon the completion of the proposed Wilson Valley Dam the Applicant will provide for releases of water into the streambed of Cache Creek between Wilson Valley Dam and Capay Dam, for the protection, propagation, and preservation of fish and wildlife involved, as follows:

In such quantities as to provide at all times at least a minimum of ten (10) cubic feet per second at all points between Wilson Valley Dam and Capay Dam; said quantity of water shall be maintained irrespective of any existing diversions upstream from Capay Dam.

and, (2) that if the proposed Indian Valley Dam is constructed and the proposed Wilson Valley Dam is not constructed, upon completion of construction of said Indian Valley Dam, the Applicant will provide for releases of water into the streambed of the North Fork of Cache Creek at Indian Valley Dam for the protection, propagation, and preservation of fish and wildlife involved, as follows:

In such quantities as to amount at all times to ten (10) cubic feet per second or the natural flow at the Indian Valley Dam site, whichever is the lesser.

IT IS FURTHER AGREED that if the proposed terms and conditions are included in such permits substantially as aforesaid, the protest of the CALIFORNIA DEPARTMENT OF FISH AND GAME to said applications nos. 11389, 15975, 15976 and 15977, may be considered withdrawn and may be dismissed.

COUNTY OF YOLO, Applicant

CALIFORNIA DEPARTMENT OF
FISH AND GAME,
Protestant

By _____
ATTEST: CHARLES S. PAYNTON,
Clerk of the Board

By _____
DIRECTOR

By: _____ Deputy.
APPROVED AS TO FORM:

STANLEY MOSK, Attorney General
J.M.SANDERSON, Deputy Attorney General
LLOYD HINKELMAN, Deputy Attorney General

By _____
LLOYD HINKELMAN
Attorneys for Protestant, CALIFORNIA
DEPARTMENT OF FISH AND GAME.

APPROVED TO FORM:
ANTHONY B. AVILIA, DISTRICT ATTORNEY
OF YOLO COUNTY

By _____
Deputy District Attorney

A P P E N D I X B

APPENDIX B
ESTIMATES OF COST

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B-3	Estimated Cost of Wilson Valley Demand Reservoir
B-5	Estimated Cost of Brooks Dam and Reservoir
B-7	Estimated Cost of Clear Lake Outlet Enlargement
B-8	Estimated Cost of Indian Valley Dam and Reservoir
B-9	Estimated Cost of Sacramento River Import Plan

ESTIMATED COST OF WILSON VALLEY DAM AND RESERVOIR
WITH 1,000,000 ACRE-FOOT STORAGE CAPACITY

(Based on prices prevailing in June, 1960)

Elevation of crest of dam:

1,244 feet, USGS datum

Elevation of crest of spillway:

1,228 feet

Height of spillway crest,

above stream bed: 361 feet

Capacity of reservoir to crest of
spillway: 1,000,000 acre-feet

Capacity of spillway with 6-foot
freeboard: 45,000 second-feet

Item	Unit	Quantity	Unit price	Cost
Access road, Highway 20 to dam site	lump sum			\$ 300,000
<u>Dam</u>				
Diversion and care of stream	lump sum			600,000
Stripping and preparation of foundation	cu yd	886,050	\$ 1.75	1,550,600
<u>Grouting</u>				
Drilling	lin ft	11,400	5.00	57,000
Pressure grout	cu ft	17,100	4.00	68,400
<u>Embankment</u>				
Pervious (new excavation)	cu yd	5,193,000	1.27	6,595,000
Pervious (salvage)	cu yd	1,468,400	0.20	293,700
Impervious	cu yd	1,934,710	0.80	1,547,800
Riprap	cu yd	4,220	6.40	27,000
Subtotal				\$10,739,500
<u>Spillway</u>				
Excavation	cu yd	1,378,000	\$ 1.85	\$ 2,549,300
<u>Concrete</u>				
Weir and lining	cu yd	5,647	50.00	282,400
Retaining walls	cu yd	1,322	80.00	105,800
Structural	cu yd	910	90.00	81,900
Reinforcing steel	lb	1,126,100	0.17	191,400
Drains	lin ft	6,500	5.00	32,500
Grouting	lump sum			10,600
Radial gate, 40" x 30"	ea	1		49,500
Radial gate hoist	ea	1		21,300
Subtotal				\$ 3,324,700
<u>Outlet Works</u>				
<u>Tunnel</u>	lin ft	1,679	\$ 1,260.00	\$ 2,115,500
<u>Excavation</u>				
Inlet portal	cu yd	80,700	1.75	141,200
Outlet portal and stilling basin	cu yd	55,000	1.75	96,200
<u>Concrete</u>				
Inlet structure				
Lining	cu yd	180	80.00	14,400
Structural	cu yd	120	90.00	10,800
Outlet structure				
Foundation	cu yd	33	50.00	1,700
Structural	cu yd	120	90.00	10,800

ESTIMATED COST OF WILSON VALLEY DAM AND RESERVOIR
WITH 1,000,000 ACRE-FOOT STORAGE CAPACITY (continued)

Item	: Unit	: Quantity	: Unit price	: Cost
<u>Outlet Works (continued)</u>				
<u>Concrete (continued)</u>				
Stilling basin				
Lining	cu yd	360	\$ 50.00	\$ 18,000
Retaining walls	cu yd	184	80.00	14,700
Structural	cu yd	61	90.00	5,500
Gate chamber plug				
Semistructural	cu yd	830	80.00	66,400
Reinforcing steel	lb	187,200	0.17	31,800
Steel pipe				
2 each, 72" diameter, 7/16" plate, 1,280' long	lb	915,000	0.30	274,500
Pipe supports	lump sum			32,900
Miscellaneous metal (trashrack, stop logs, etc.)	lb	500,000	0.30	150,000
High-pressure gate valves, 4½' x 4½'	ea	2	61,600.00	123,200
Howell-Bunger valves, 66" diameter	ea	2	72,000.00	144,000
Riprap	cu yd	350	6.40	2,200
Air vent, 12" diameter	lin ft	424	50.00	21,200
Subtotal				\$3,275,000
<u>Reservoir</u>				
Land and improvements	lump sum			\$ 930,000
Clearing	ac	9,000	\$ 100.00	900,000
State highway relocation*	lump sum			6,737,000
Subtotal				\$ 8,567,000
TOTAL ALL ITEMS				\$26,206,000
Engineering and administration				2,969,000
Contingencies				3,390,000
Interest during construction, 4 percent for 1/2 of 3-year period				1,950,000
TOTAL CAPITAL COST				\$34,515,000
<u>ANNUAL COST (4 percent for 50 years)</u>				
Interest, 4 percent				\$ 1,380,600
Repayment, 0.655 percent				226,100
Replacement, 0.07 percent				24,200
General expense, 0.32 percent				110,400
Operation and maintenance				78,000
TOTAL ANNUAL COST				\$ 1,819,300

*Includes \$1,735,000 for improvement to expressway standards.

ESTIMATED COST OF BROOKS DAM AND RESERVOIR

(Based on prices prevailing in spring, 1960)

Type of dam: concrete overpour	Storage capacity of reservoir to spillway crest: 6,200 acre-feet
Elevation of crest of dam: 290 feet USGS datum	Discharge capacity of spillway with no free-board: 47,300 second-feet
Elevation of crest of spillway: 280 feet	
Height of spillway crest, above stream bed: 40 feet	

Item	Unit	Quantity	Unit price	Cost
CAPITAL COST				
<u>Dam and Spillway</u>				
Diversion and care of stream	lump sum			\$ 20,000
Stripping				
Abutments	cu yd	3,820	\$.30	1,200
Channel	cu yd	4,920	1.00	4,900
Foundation preparation	sq yd	1,890	4.00	7,600
Apron excavation	cu yd	22,700	1.00	22,700
Mass concrete	cu yd	21,200	35.00	742,000
Structural concrete	cu yd	6,676	50.00	333,800
Steel reinforcing	lb	671,400	.15	100,700
Grouting				
Drilling	lin ft	1,850	5.00	9,200
Pressure grout	cu ft	925	4.00	3,700
Subtotal				\$1,245,800
<u>Outlet Works</u>				
Slide gates and hoists	ea	4	\$2,000.00	\$ 8,000
Installation	lump sum			1,200
Steel conduit	lb	5,150	.25	1,300
Miscellaneous metal work	lump sum			5,000
Subtotal				\$ 15,000
<u>Reservoir</u>				
Hill lands	ac	260	\$ 60.00	\$ 15,600
Valley lands	ac	750	200.00	150,000
Subtotal				\$ 165,600
TOTAL ALL ITEMS				\$1,426,400
Administration and engineering, 10 percent				142,600
Contingencies, 15 percent				213,900
Interest during construction				35,700
TOTAL CAPITAL COST				\$1,818,600

ESTIMATED COST OF BROOKS DAM AND RESERVOIR

(Based on prices prevailing in spring, 1960)

Item	:	Unit	:	Quantity	:	Unit price	:	Cost
ANNUAL COST								
Interest, 4.0 percent						\$		72,700
Repayment, 0.655 percent								11,800
Replacement, 0.07 percent								1,300
General expense, 0.32 per-								
cent								5,800
Operation and maintenance								6,000
TOTAL ANNUAL COST						\$		97,600

ESTIMATED COST OF CLEAR LAKE
OUTLET CHANNEL ENLARGEMENT

Discharge capacity of
channel at lake
elevation 7.56:
8,500 second-feet

Length of channel: 4.9 miles

Item	Unit	Quantity	Unit price	Cost
CAPITAL COST				
<u>Excavation</u>				
Sta. 0+00 to Sta. 92+00	cu yd	412,000	\$ 0.40	\$ 164,800
Sta. 92+00 to Sta. 115+00	cu yd	106,000	3.00	318,000
Sta. 115+00 to Sta. 130+00	cu yd	74,000	1.00	74,000
Sta. 130+00 to Sta. 150+00	cu yd	60,000	0.80	48,000
Sta. 150+00 to Sta. 244+50	cu yd	167,000	0.40	66,800
Sta. 244+50 to Sta. 260+00	cu yd	0	----	0
				\$ 671,600
Retaining walls, concrete	lump sum			\$ 60,000
Highway 53 bridge footings	lump sum			50,000
Right of way and reloca- tion of utilities	lump sum			200,000
Subtotal				\$ 981,600
Engineering and Adminis- tration				98,200
Contingencies				147,300
Interest during construction				23,000
TOTAL CAPITAL COST				1,250,100
ANNUAL COST (4 percent for 50 years)				
Interest, 4 percent			\$	50,000
Repayment, 0.655 percent				8,200
Replacement, 0.07 percent				900
General expense, 0.32 per- cent				4,000
Operation and maintenance				5,000
TOTAL ANNUAL COST			\$	68,100

ESTIMATED COST OF CACHE CREEK-SACRAMENTO
RIVER DIVERSION PROJECT

(Based on prices prevailing in 1960)

Indian Valley Dam and Reservoir

Elevation of crest of dam: 1,470 feet, USGS datum	Capacity of reservoir to crest of spillway: 200,000 acre-feet
Elevation of crest spillway: 1,457 feet	Capacity of spillway with 3-foot freeboard: 20,000 second-feet
Height of spillway crest above stream bed: 167 feet	

Item	:	Cost
 CAPITAL COST		
Earthfill embankment		\$1,330,000
Spillway		1,020,000
Outlet works		180,000
Reservoir land acquisitions		400,000
Relocation of roads and utilities		<u>144,000</u>
Subtotal		\$3,074,000
Engineering and administration		\$ 307,000
Contingencies		461,000
Interest during construction		<u>154,000</u>
TOTAL CAPITAL COST		\$3,976,000

ANNUAL COST

Interest, 4.0 percent	\$ 159,000
Repayment, 0.655 percent	26,000
Replacement, 0.07 percent	2,800
General expense, 0.32 percent	12,700
Operation and maintenance	<u>18,500</u>
TOTAL ANNUAL COST	\$ 219,000

ESTIMATED COST OF CACHE CREEK-SACRAMENTO RIVER
DIVERSION PROJECT

Sacramento River Diversion

Average seasonal
diversion:
100,000 acre-feet
Design discharge capacity:
400 second-feet

Item	:	Cost
CAPITAL COST		
Concrete lined canals		\$3,365,000
Hydraulic structures		481,000
Bridges		846,000
Pumping plants		1,720,000
Rights of way		<u>545,000</u>
Total		\$6,957,000
ANNUAL COST		
Interest, 4.0 percent	\$	278,300
Repayment, 0.655 percent		45,600
Replacement (varies)		51,300
General expense, 0.32 percent		22,300
Operation and maintenance		99,500
Electric energy		<u>166,400</u>
Total	\$	663,400

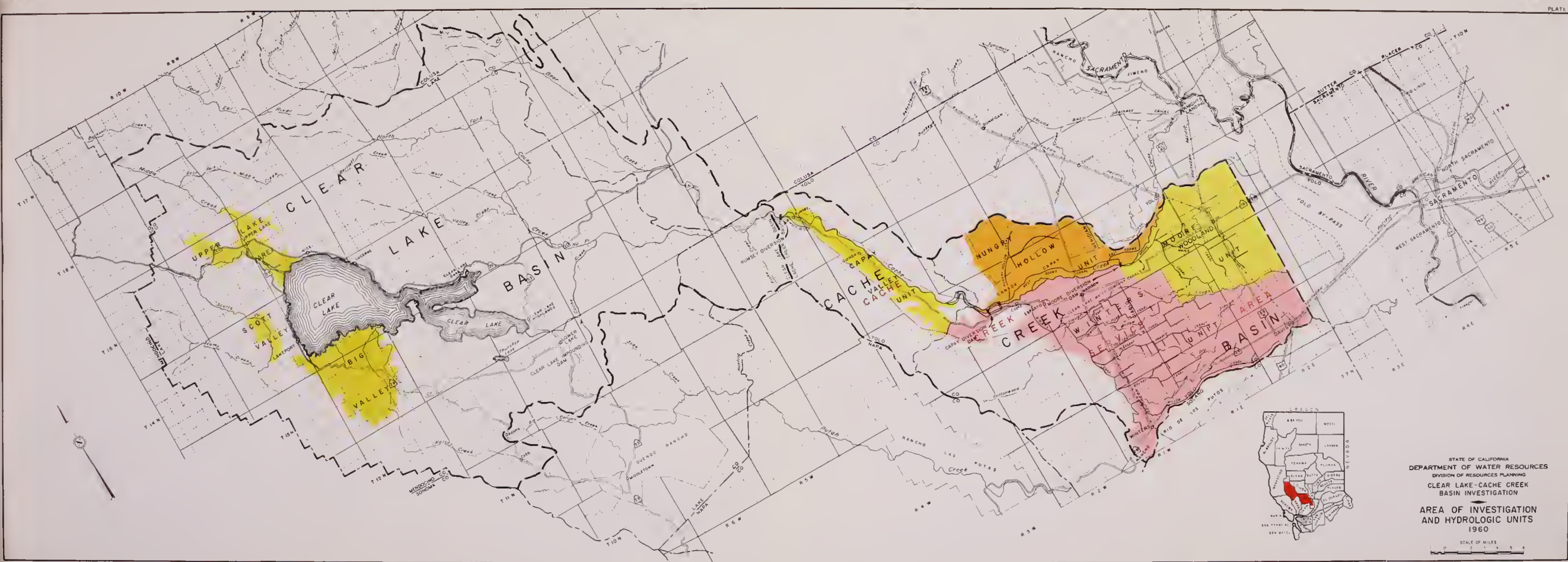
A P P E N D I X C

SEASONAL SUMMARY OF MONTHLY OPERATION OF CLEAR LAKE AND WILSON VALLEY RESERVOIR (In acre-feet)

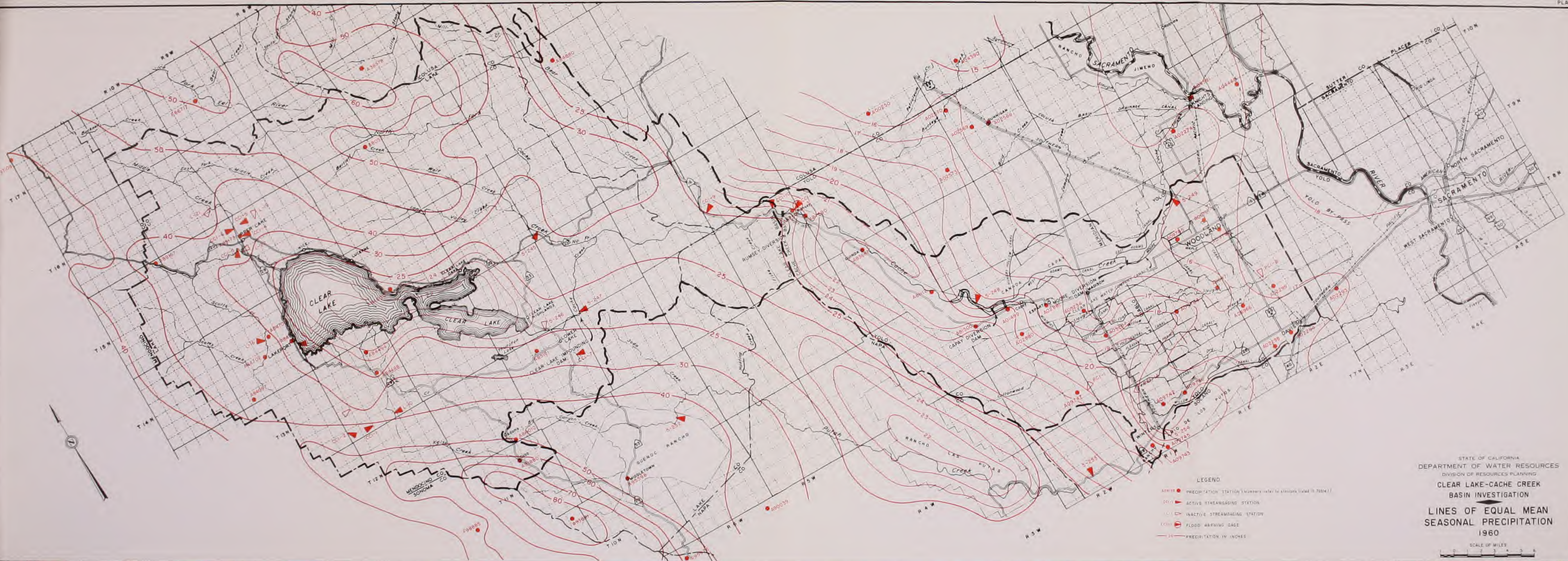
Gross Storage Capacity
Clear Lake
Wilson Valley

Acres-feet
311,000
1,000,000

Season	Clear Lake										Wilson Valley Reservoir									
	Inflow	Evaporation	Upstream depletion	Spill	Septem-ber 30	Release to Wilson Valley	Inflow to Wilson Valley	Total Inflow to Wilson Valley	Evapo-ration	Spill	Septem-ber 30	Release from Wilson Valley	Lower Cache Creek runoff	Seasonal yield at Capay						
1913 - 14	873,100	230,400	20,800	383,500	1,044,800	34,800	394,500	812,800	18,100	0	588,900	210,000	23,000	233,000						
14 - 15	762,000	206,400	20,800	528,600	1,051,100	0	320,900	819,500	20,200	392,300	812,900	207,000	26,000	233,000						
15 - 16	1,922,900	224,100	20,800	270,100	1,029,000	0	320,500	1,900,600	22,500	343,500	722,900	220,600	12,400	233,000						
16 - 17	305,000	217,400	20,800	70,900	1,024,800	0	134,300	205,200	21,300	0	706,400	200,500	32,500	233,000						
17 - 18	205,700	225,500	20,800	0	984,300	0	53,500	53,500	19,000	0	535,800	205,100	27,900	233,000						
18 - 19	366,200	217,800	20,800	72,600	1,039,300	0	122,400	194,900	17,200	0	475,200	238,100	- 5,400	233,000						
19 - 20	118,500	212,300	20,800	0	924,700	0	29,600	29,600	12,700	0	266,800	225,200	7,800	233,000						
1920 - 21	633,700	206,400	20,800	274,700	1,056,500	0	203,500	478,100	16,100	0	505,900	223,000	10,000	233,000						
21 - 22	318,400	227,200	20,800	78,200	1,048,700	0	97,300	175,500	17,100	0	443,900	220,100	12,900	233,000						
22 - 23	339,000	235,100	20,800	75,900	1,055,900	0	106,800	182,700	15,300	0	385,200	226,100	6,900	233,000						
23 - 24	110,100	218,300	20,800	0	926,800	0	25,300	25,300	13,100	0	166,900	230,500	2,500	233,000						
24 - 25	515,100	192,000	20,800	152,000	1,077,100	0	137,600	289,700	7,000	0	232,600	216,900	16,100	233,000						
1925 - 26	335,600	189,000	20,800	163,100	1,039,500	0	136,300	299,700	11,000	0	299,600	221,700	11,300	233,000						
26 - 27	771,700	199,600	20,800	510,900	1,050,000	0	204,100	715,000	19,300	11,500	793,900	219,900	13,100	233,000						
27 - 28	1,290,000	209,700	20,800	206,800	1,041,700	0	126,100	332,900	22,000	104,900	782,600	217,200	15,800	233,000						
28 - 29	167,800	213,700	20,800	0	975,100	0	38,800	38,800	20,100	0	579,000	222,200	10,900	233,000						
29 - 30	363,100	210,300	20,800	51,100	1,056,000	0	129,600	181,100	17,700	0	503,100	239,400	- 6,400	233,000						
1930 - 31	134,100	233,800	20,800	0	935,800	0	18,500	18,500	12,600	0	282,900	226,000	7,000	233,000						
31 - 32	286,300	215,100	20,800	0	986,200	0	83,000	83,000	9,000	0	129,800	227,000	6,000	233,000						
32 - 33	194,300	213,500	20,800	0	863,100	70,100	44,500	114,600	4,000	0	31,000	219,200	13,800	233,000						
33 - 34	251,200	204,600	20,800	251,200	0	814,400	57,800	121,100	2,600	0	31,000	118,500	- 4,000	114,500						
34 - 35	422,900	190,700	20,800	0	932,800	79,100	129,300	208,600	2,500	0	31,000	216,700	16,300	233,000						
1935 - 36	425,900	200,000	20,800	69,200	1,057,000	10,700	165,300	245,200	5,100	0	51,800	219,300	13,700	233,000						
36 - 37	314,000	206,800	20,800	99,900	1,023,100	17,600	89,500	207,000	4,800	0	31,000	222,900	10,100	233,000						
37 - 38	789,800	191,100	20,800	543,900	1,052,000	4,200	459,800	1,008,000	16,900	35,000	784,000	203,100	29,900	233,000						
38 - 39	152,500	210,400	20,800	0	973,300	0	23,100	23,100	18,000	0	565,400	223,800	9,200	233,000						
39 - 40	598,900	198,500	20,800	309,300	1,043,700	0	256,100	565,700	19,500	110,700	789,300	211,600	21,400	233,000						
1940 - 41	889,700	191,900	20,800	667,400	1,053,400	0	483,700	1,151,000	17,400	899,400	832,400	191,200	44,800	233,000						
41 - 42	749,200	197,300	20,800	513,000	1,071,500	0	273,800	786,800	18,500	571,500	815,000	214,200	18,800	233,000						
42 - 43	523,700	205,900	20,800	304,600	1,064,000	0	149,400	453,900	20,100	273,000	730,300	215,400	-12,400	233,000						
43 - 44	229,600	193,700	20,800	37,600	1,041,300	0	96,100	134,000	17,800	0	623,700	222,800	10,200	233,000						
44 - 45	306,800	198,000	20,800	94,400	1,034,900	0	92,200	186,700	16,400	0	564,400	229,600	3,400	233,000						
1945 - 46	411,700	197,400	20,800	202,800	1,025,600	0	150,100	352,900	17,900	0	674,900	224,600	8,400	233,000						
46 - 47	209,800	205,500	20,800	0	1,009,000	0	43,800	43,800	16,300	0	479,200	223,200	9,800	233,000						
47 - 48	267,000	167,000	20,800	36,200	1,051,900	0	72,900	109,900	9,200	0	356,200	222,800	10,200	233,000						
48 - 49	361,000	266,900	20,800	104,300	1,021,300	0	92,500	196,900	16,900	0	305,000	231,200	1,800	233,000						
49 - 50	360,300	308,000	20,800	33,700	1,013,100	0	74,900	108,600	15,000	0	173,600	225,000	8,000	233,000						
1950 - 51	593,600	277,700	20,800	273,100	1,041,100	0	190,400	463,500	18,800	0	406,400	211,800	21,200	233,000						
51 - 52	723,000	272,800	20,800	431,000	1,039,500	0	302,200	733,200	26,700	158,000	742,700	212,700	20,300	233,000						
52 - 53	590,500	269,800	20,800	287,200	1,052,200	0	213,000	500,200	26,800	258,800	739,600	217,800	14,200	233,000						
53 - 54	460,400	260,800	20,800	192,100	1,038,600	0	143,000	335,400	26,300	51,700	782,900	214,100	13,900	233,000						
54 - 55	299,200	278,700	20,800	6,900	1,036,400	0	55,000	62,000	25,400	0	596,800	222,600	10,200	233,000						
1955 - 56	939,800	295,600	20,800	612,100	1,041,800	0	407,900	1,020,000	29,600	640,700	729,900	216,600	16,400	233,000						
56 - 57	389,600	279,400	20,800	82,700	1,048,500	0	93,300	176,000	26,500	0	660,000	219,400	13,600	233,000						
57 - 58	1,029,200	251,100	20,800	750,200	1,055,600	0	491,900	1,242,100	23,700	865,700	805,800	207,000	26,000	233,000						
45-year average	445,500	223,300	20,800	189,400		6,200	160,800	356,400	16,800	104,800		217,400	15,600	230,400						

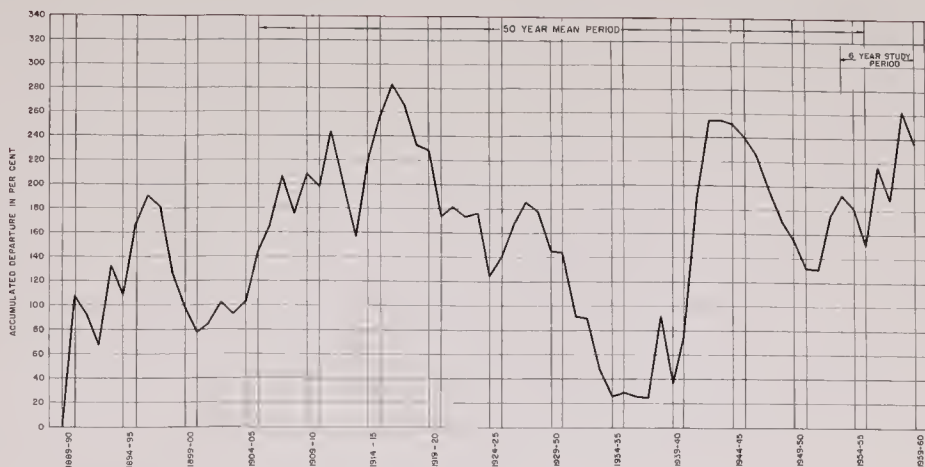


STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
DIVISION OF RESOURCES PLANNING
CLEAR LAKE-CACHE CREEK
BASIN INVESTIGATION
AREA OF INVESTIGATION
AND HYDROLOGIC UNITS
1960
SCALE OF MILES
0 1 2 3 4

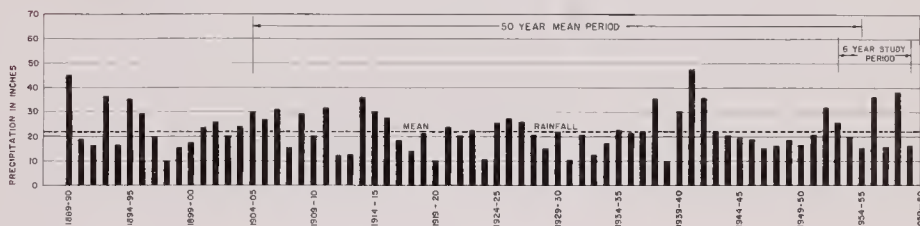


- LEGEND
- PRECIPITATION STATION (Numbers refer to station listed in Table 1)
 - ▲ ACTIVE STREAMGAGING STATION
 - INACTIVE STREAMGAGING STATION
 - ▢ FLOOD WARNING GAGE
 - PRECIPITATION IN INCHES

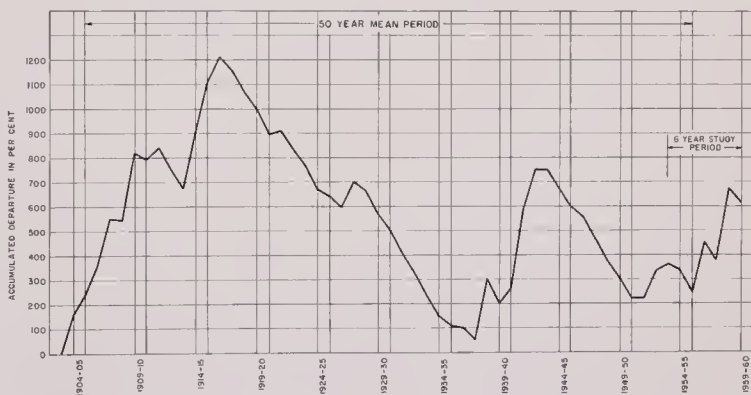
STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
DIVISION OF RESOURCES PLANNING
CLEAR LAKE-CACHE CREEK
BASIN INVESTIGATION
LINES OF EQUAL MEAN
SEASONAL PRECIPITATION
1960
SCALE OF MILES
0 1 2 3 4 5



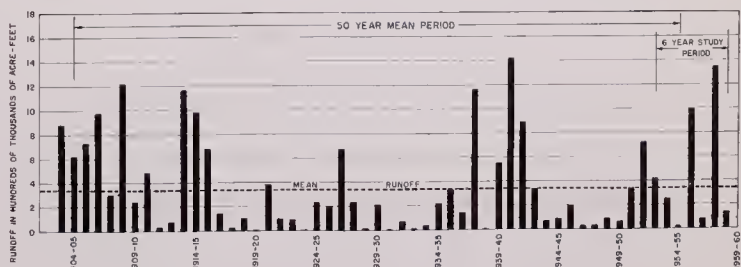
ACCUMULATED DEPARTURE FROM MEAN SEASONAL PRECIPITATION AT CAPAY



RECORDED SEASONAL PRECIPITATION AT CAPAY

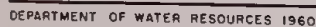


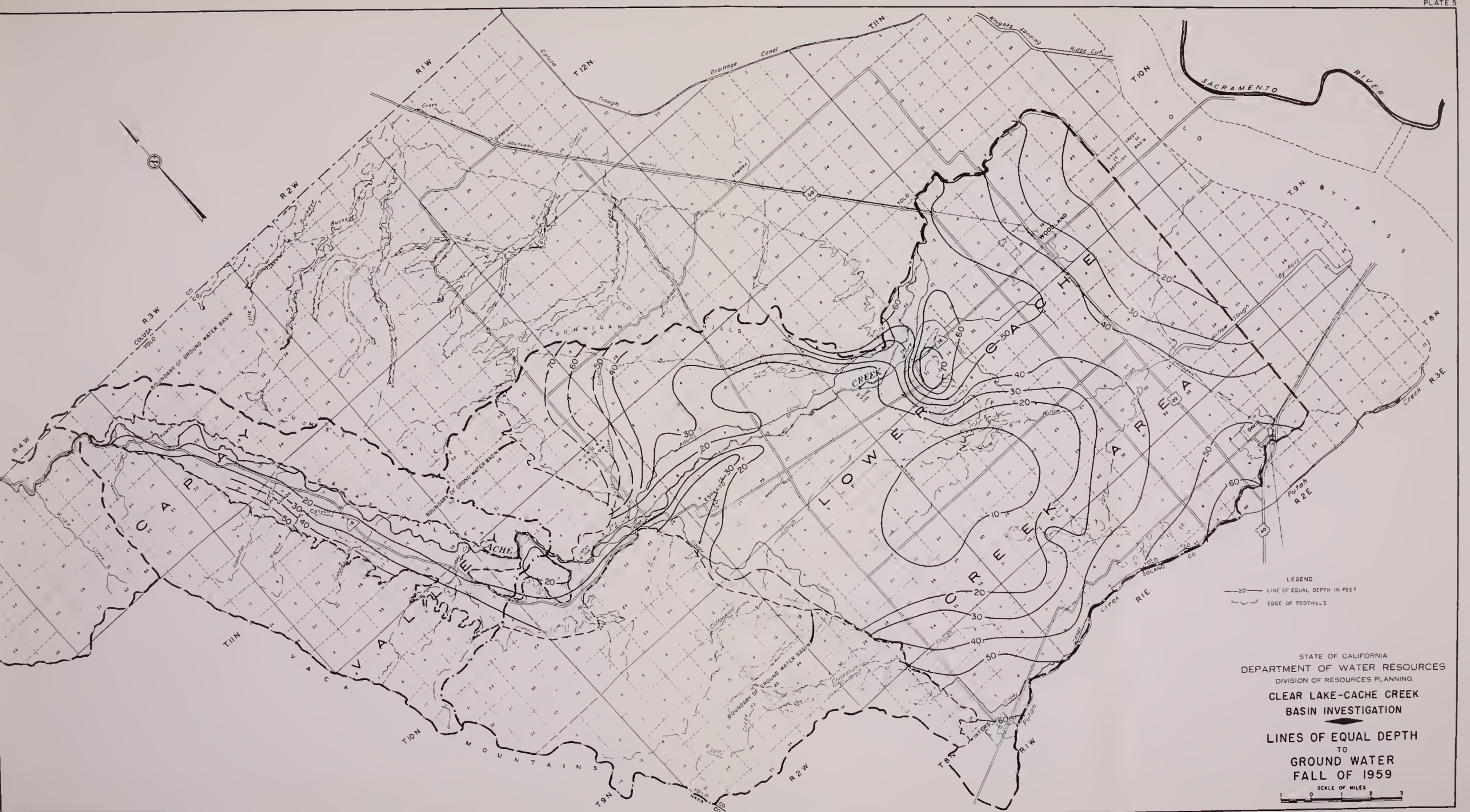
ACCUMULATED DEPARTURE FROM MEAN SEASONAL RUNOFF OF CACHE CREEK AT YOLO



RECORDED SEASONAL RUNOFF OF CACHE CREEK AT YOLO

REPRESENTATIVE PRECIPITATION AND RUNOFF CHARACTERISTICS
IN CLEAR LAKE-CACHE CREEK BASIN





LEGEND
— 20 — LINE OF EQUAL DEPTH IN FEET
- - - - - EDGE OF FOOTHILLS

STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
DIVISION OF RESOURCES PLANNING
CLEAR LAKE-CACHE CREEK
BASIN INVESTIGATION

LINES OF EQUAL DEPTH
TO
GROUND WATER
FALL OF 1959

SCALE OF MILES
0 1 2 3

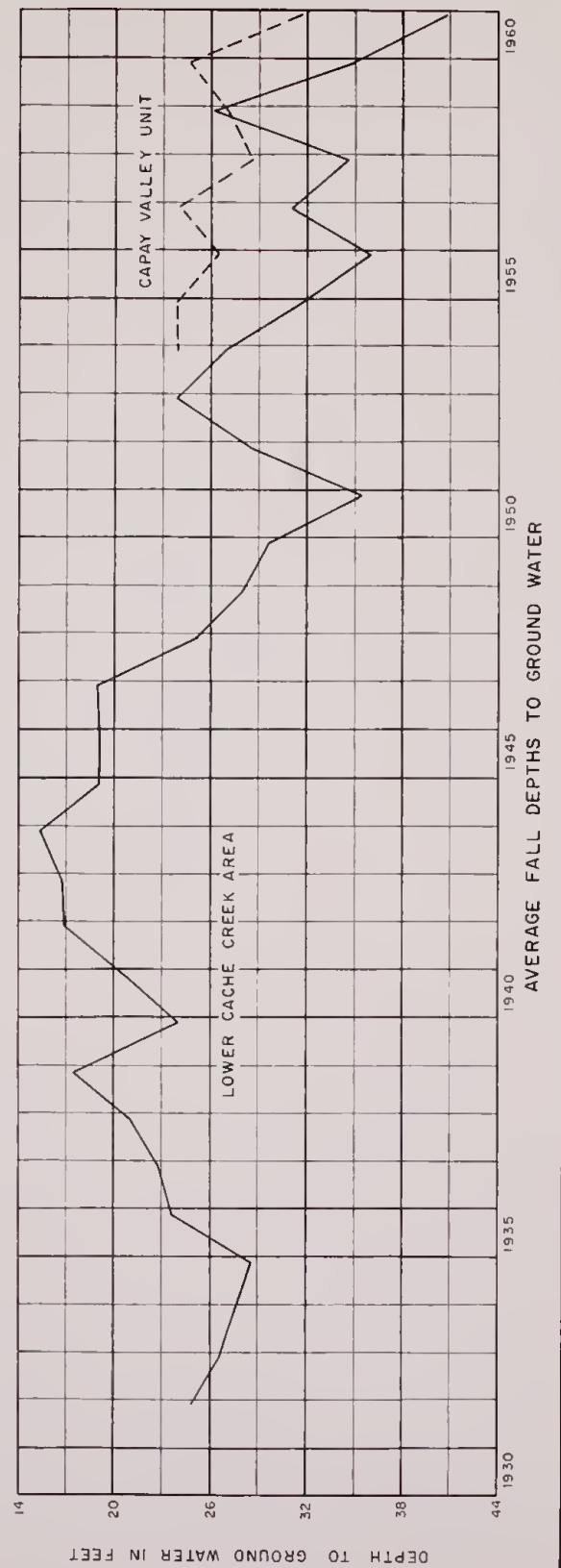
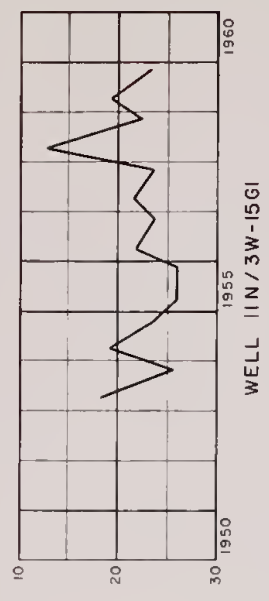
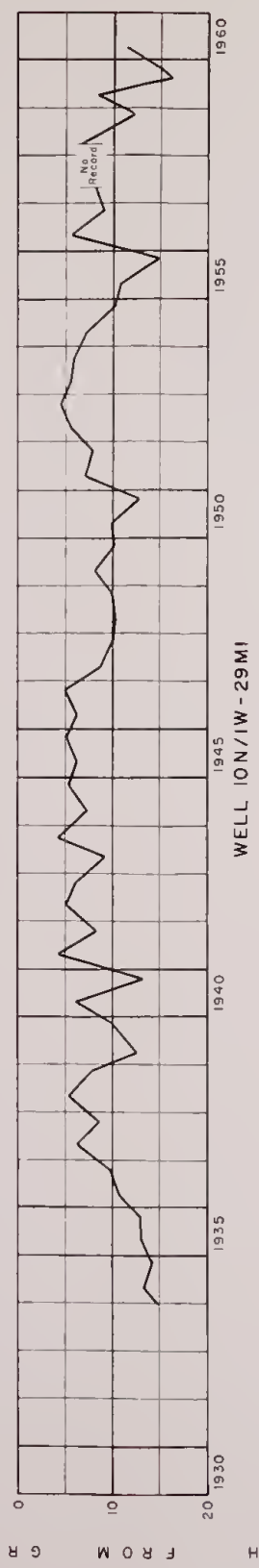
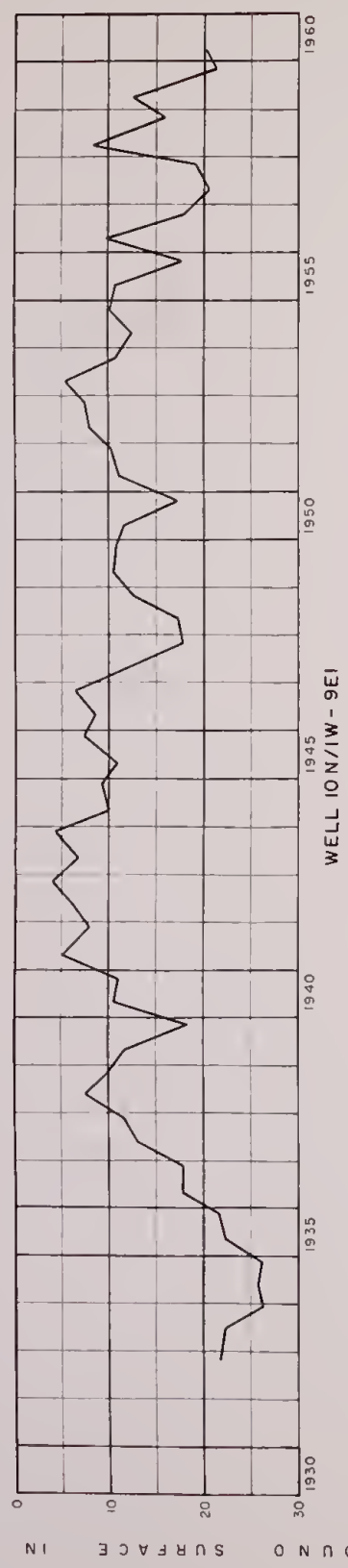
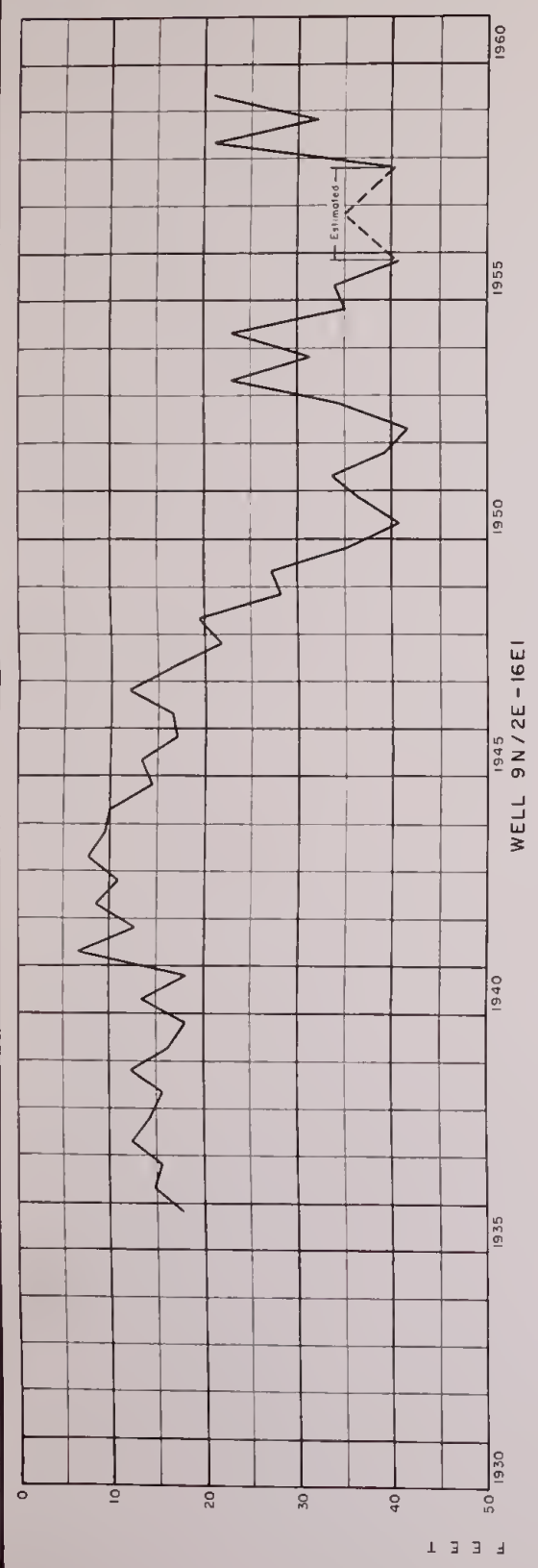


STATE OF CALIFORNIA
 DEPARTMENT OF WATER RESOURCES
 DIVISION OF RESOURCES PLANNING
 CLEAR LAKE-CACHE CREEK
 BASIN INVESTIGATION
 LINES OF EQUAL ELEVATION
 OF
 GROUND WATER
 FALL OF 1959
 SCALE OF MILES
 0 1 2 3



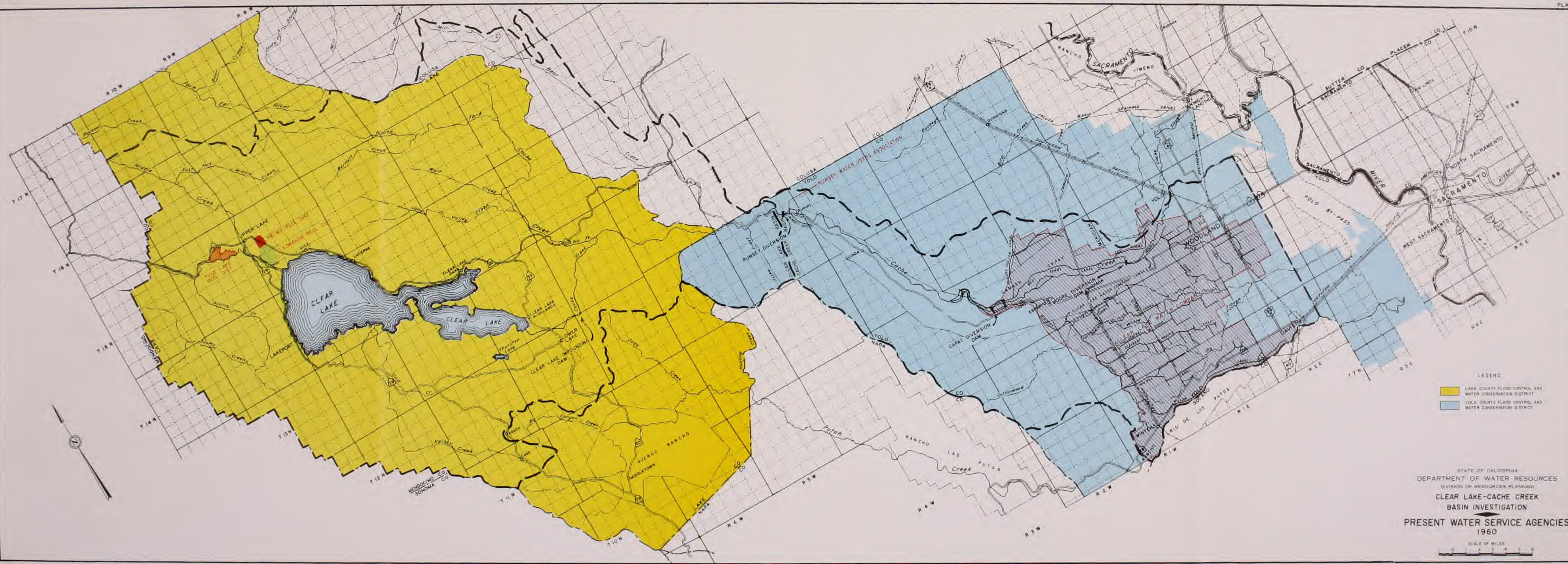
STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
DIVISION OF RESOURCES PLANNING
CLEAR LAKE-CACHE CREEK
BASIN INVESTIGATION
LINES OF EQUAL ELEVATION
OF
GROUND WATER
SPRING OF 1959
SCALE OF MILES
0 1 2 3

LEGEND
— 50 — LINES OF EQUAL ELEVATION IN FEET
- - - EDGE OF FOOTHILLS



DEPTHS TO GROUND WATER AT REPRESENTATIVE WELLS



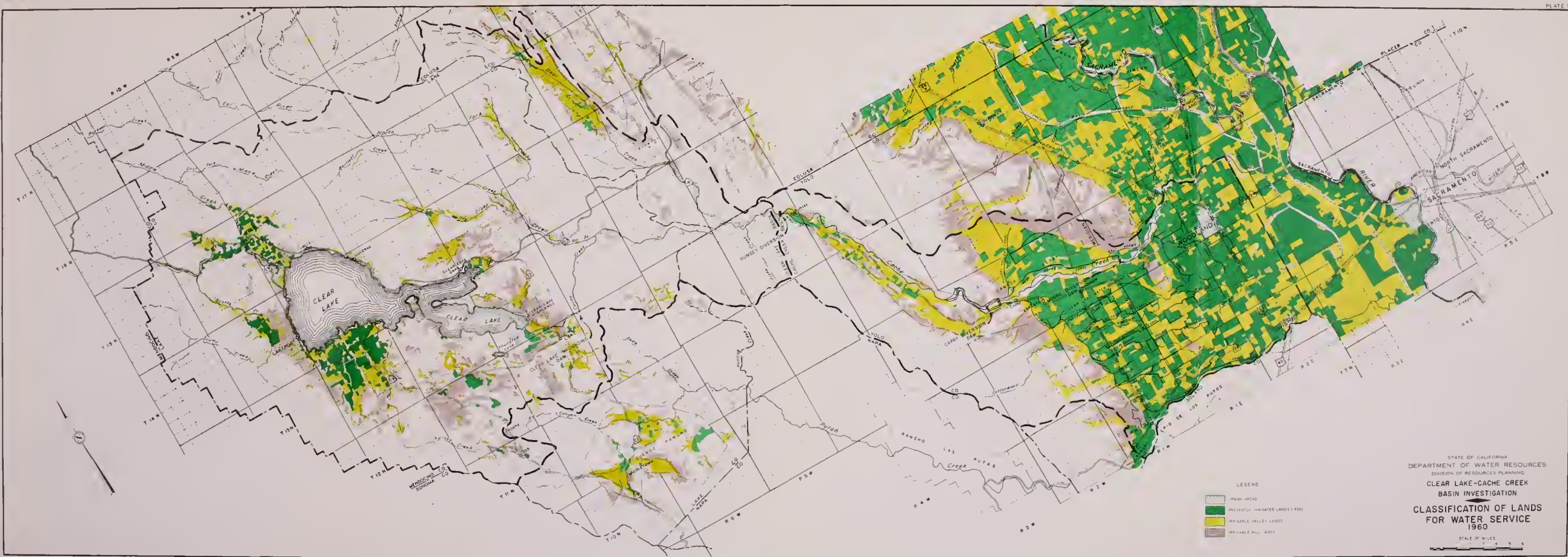


LEGEND

- LAKE COUNTY FLOOD CONTROL AND WATER CONSERVATION DISTRICT
- YOLO COUNTY FLOOD CONTROL AND WATER CONSERVATION DISTRICT

STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
DIVISION OF RESOURCES PLANNING
CLEAR LAKE-CACHE CREEK
BASIN INVESTIGATION
PRESENT WATER SERVICE AGENCIES
1960

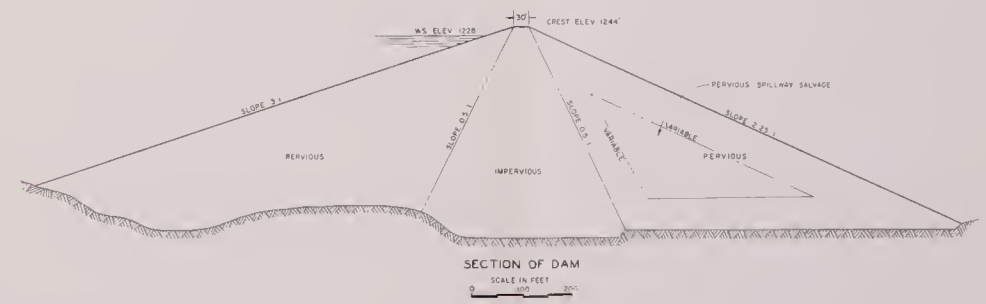
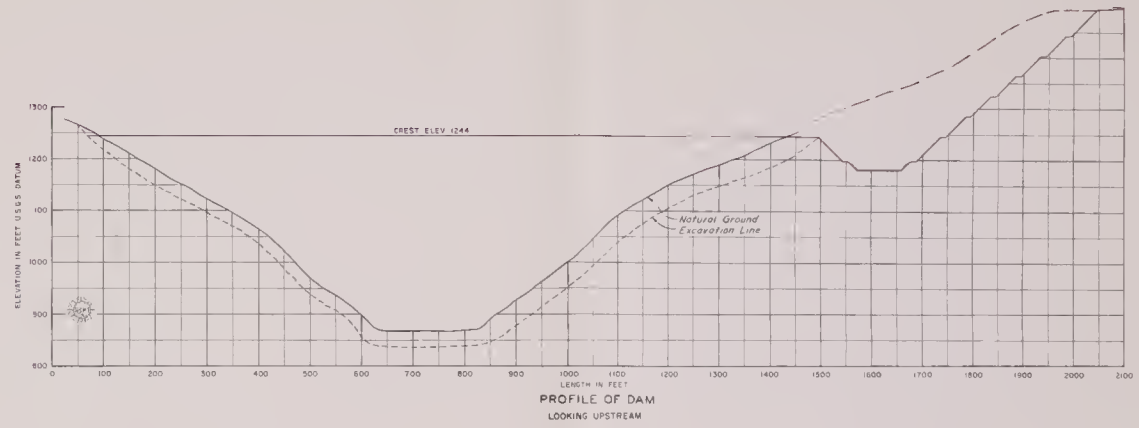
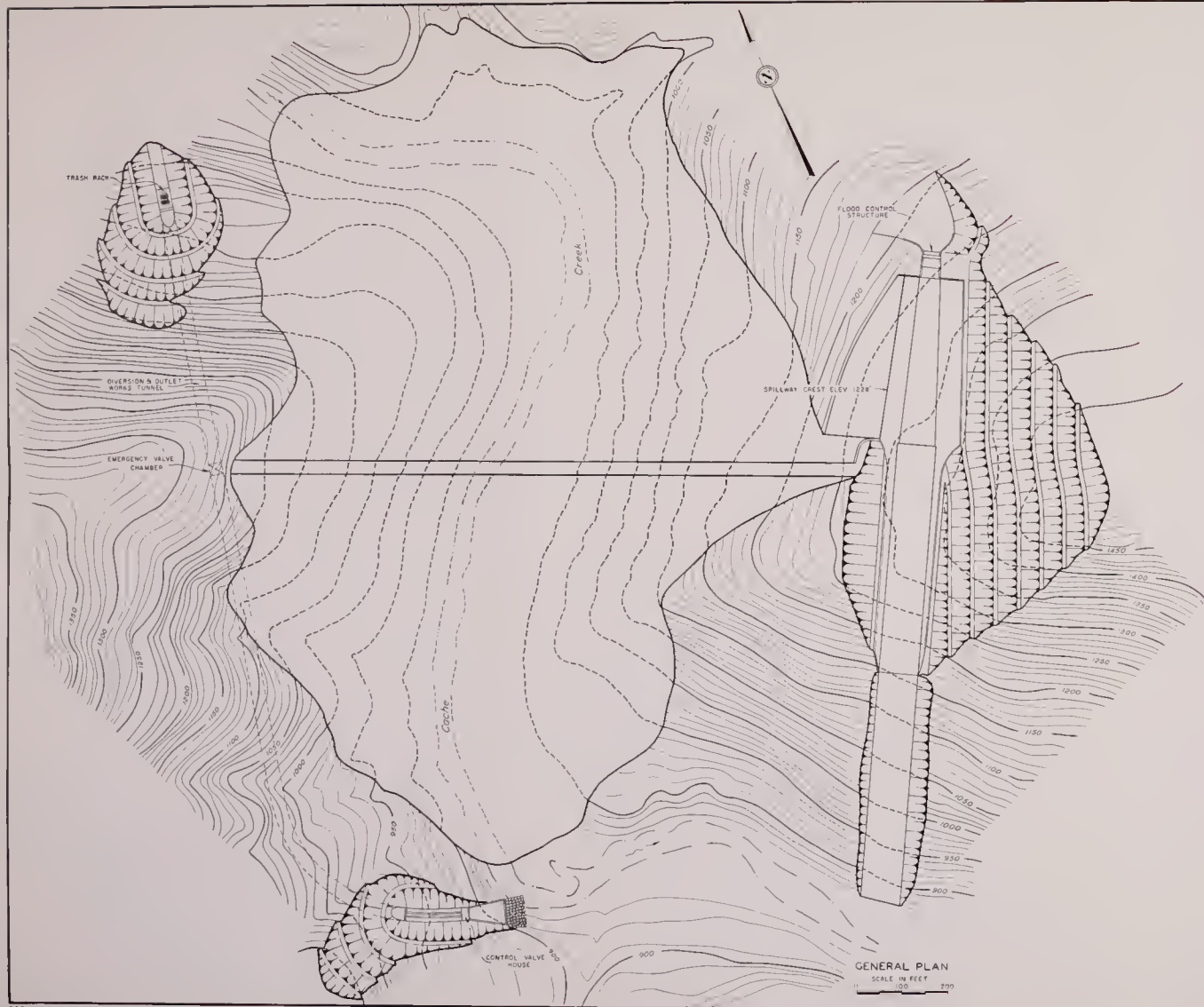
SCALE OF MILES
0 1 2 3 4 5 6



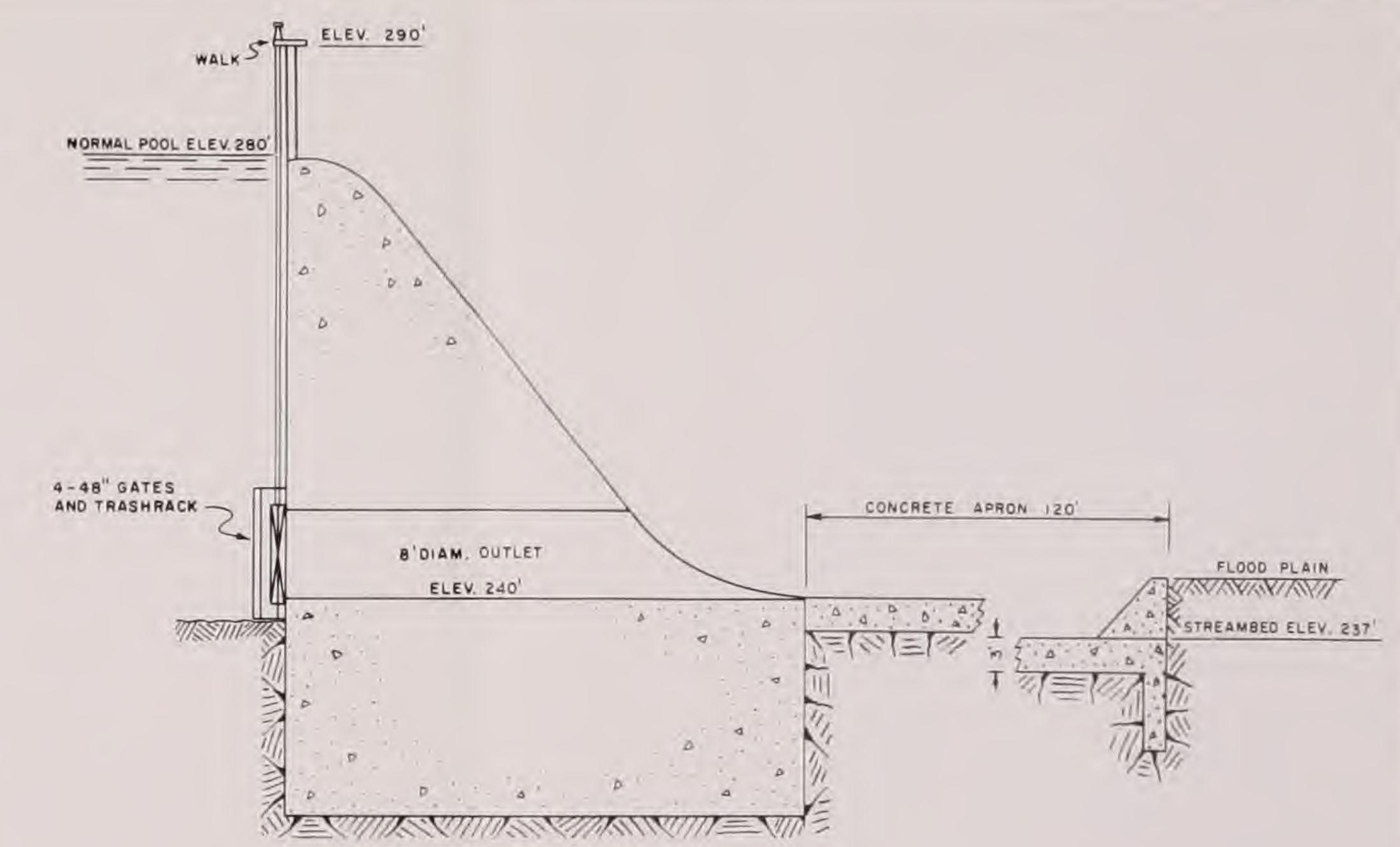
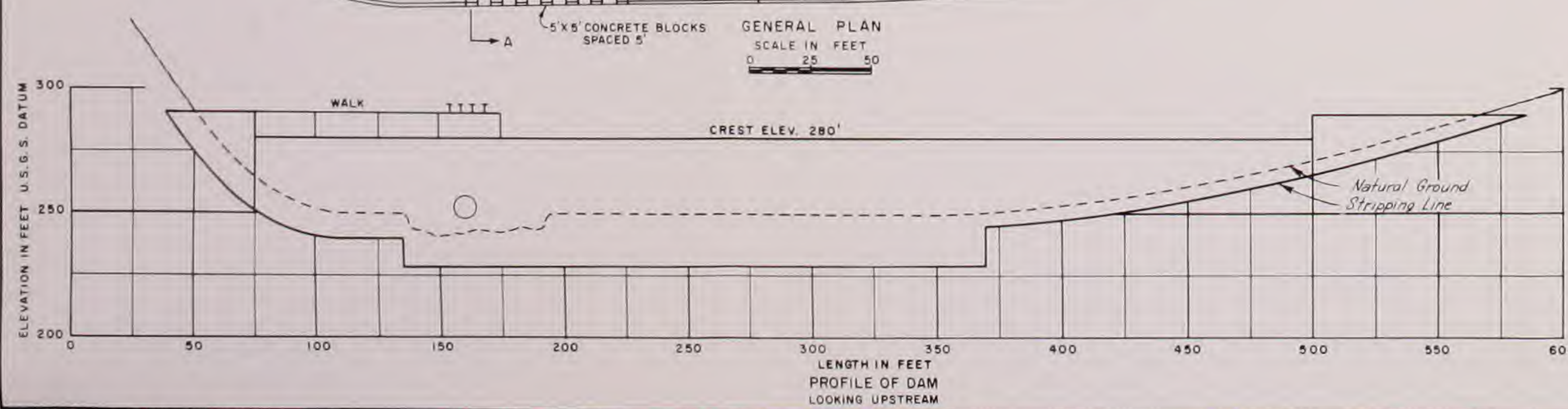
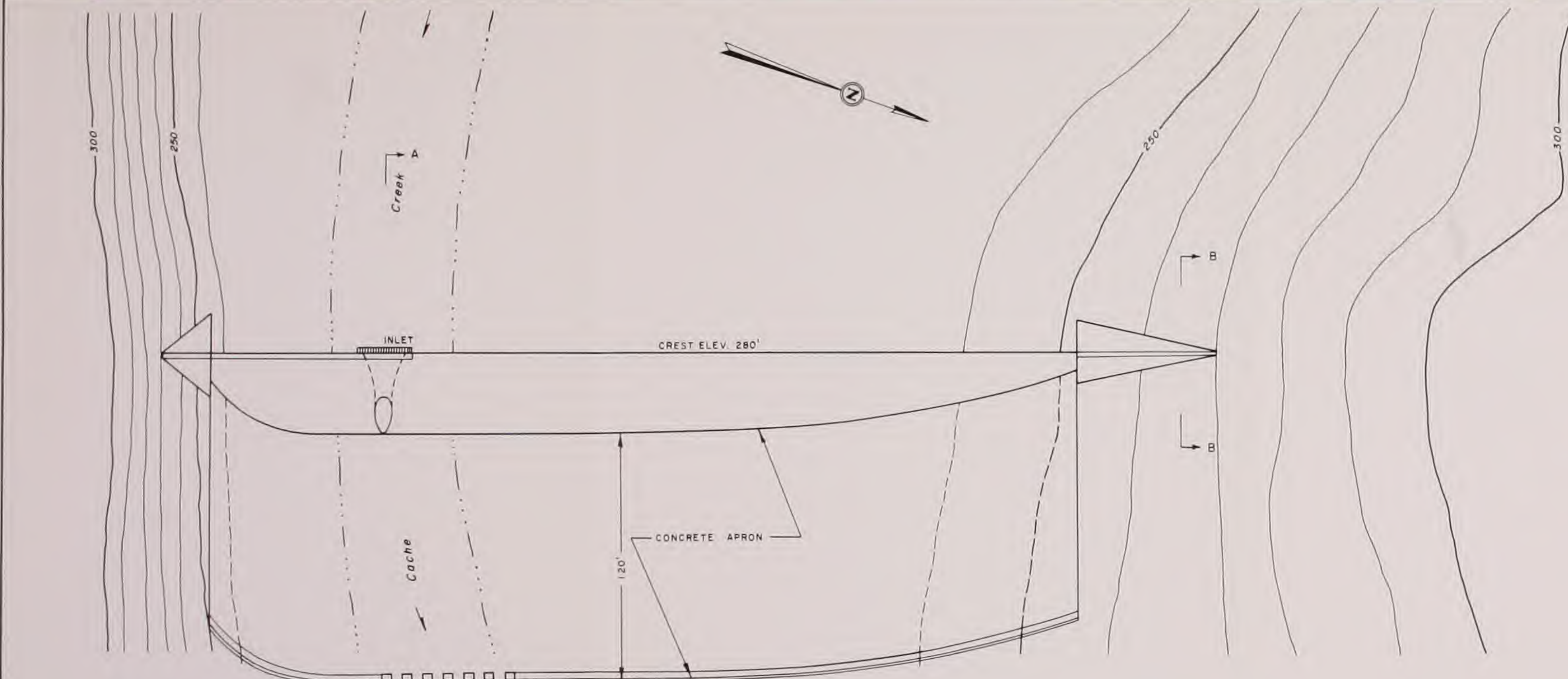
STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
DIVISION OF RESOURCES PLANNING
CLEAR LAKE-CACHE CREEK
BASIN INVESTIGATION
**CLASSIFICATION OF LANDS
FOR WATER SERVICE
1960**
SCALE OF MILES
0 1 2 3 4 5 6 7 8 9 10

DEPARTMENT OF WATER RESOURCES
DIVISION OF RESOURCES PLANNING
CLEAR LAKE-CACHE CREEK
BASIN INVESTIGATION
EXISTING AND ALTERNATIVE
WATER SUPPLY DEVELOPMENTS
1960

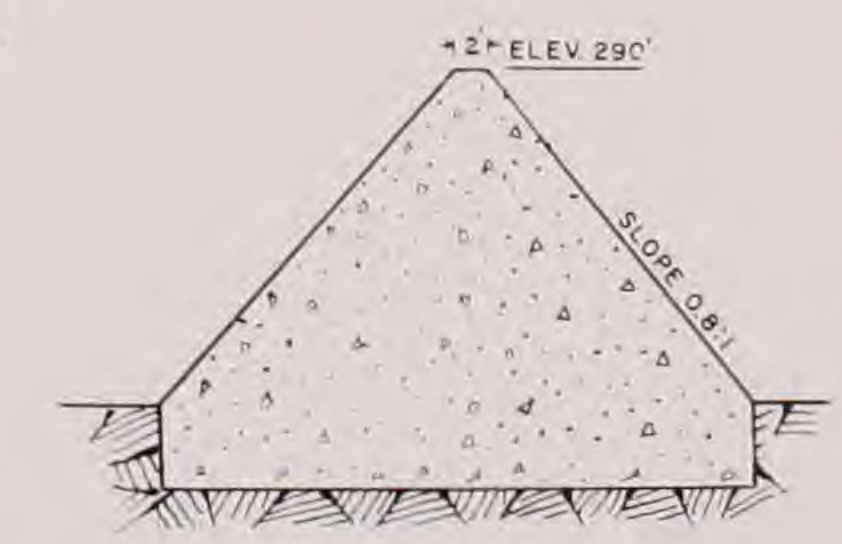
SCALE OF MILES



STATE OF CALIFORNIA
 DEPARTMENT OF WATER RESOURCES
 DIVISION OF RESOURCES PLANNING
 CLEAR LAKE-CACHE CREEK
 BASIN INVESTIGATION
 WILSON VALLEY DAM
 ON CACHE CREEK
 RESERVOIR STORAGE CAPACITY
 OF 1,000,000 ACRE-FEET

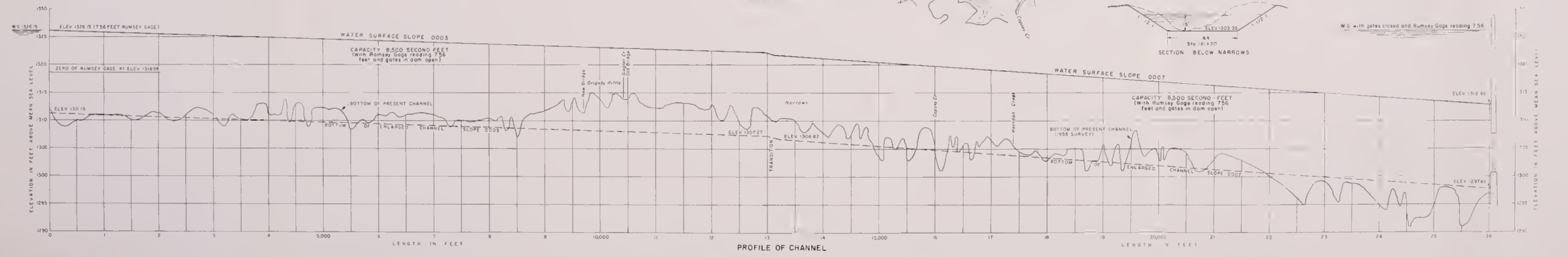
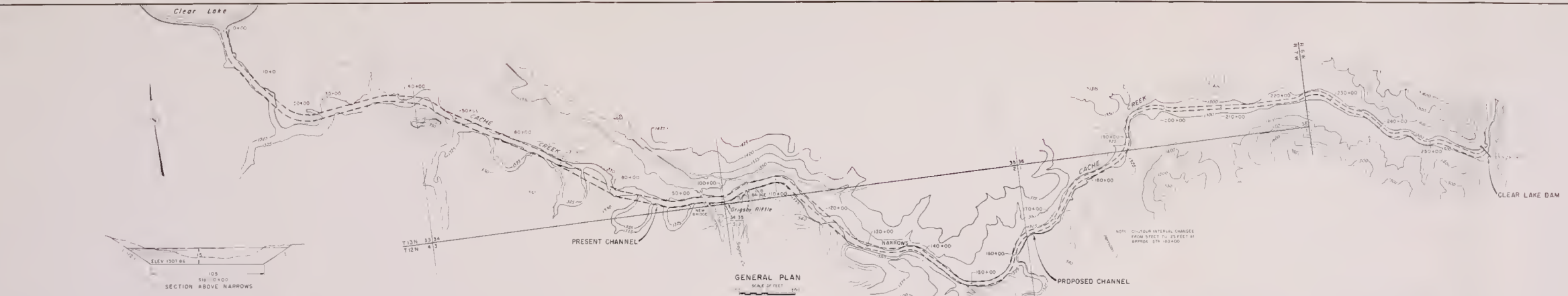


SECTION A-A
SCALE IN FEET
0 5 10 15

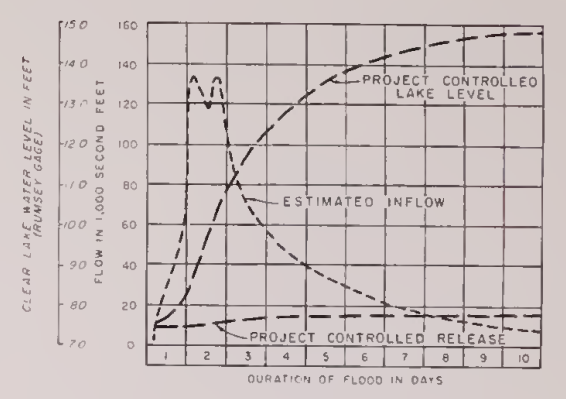
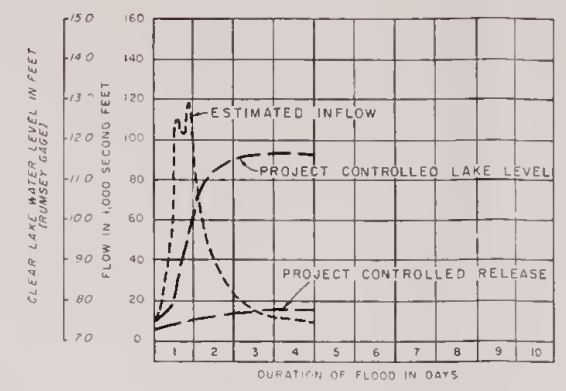
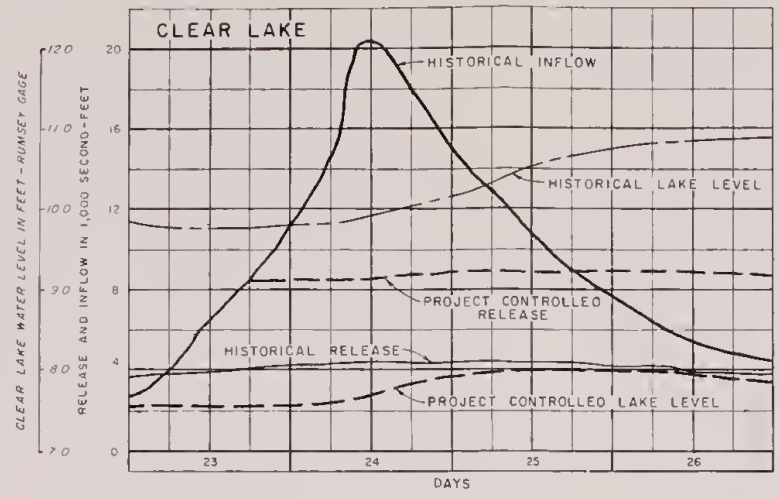
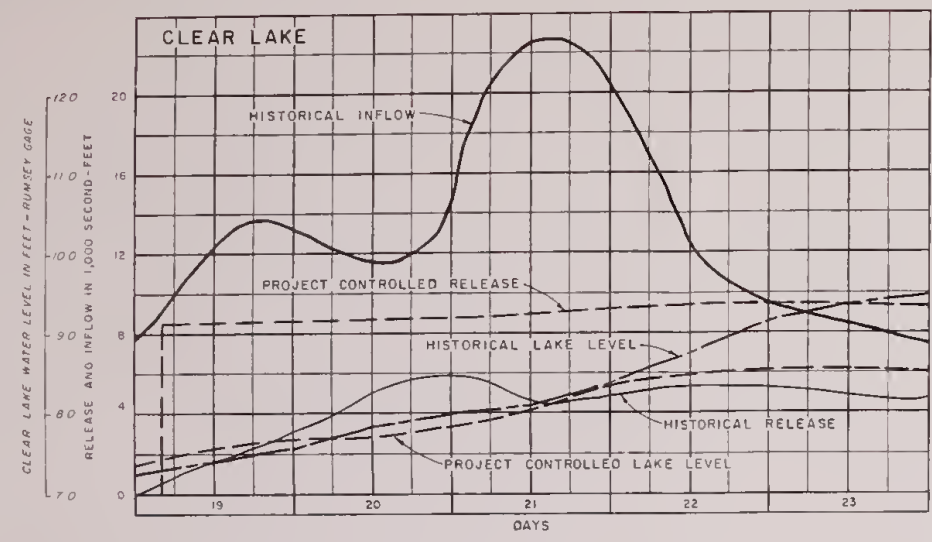


SECTION B-B
SCALE IN FEET
0 5 10 15

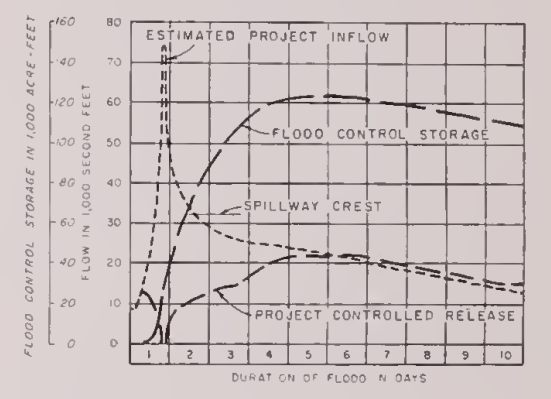
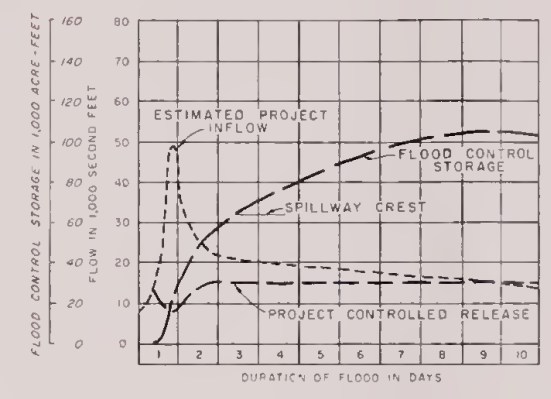
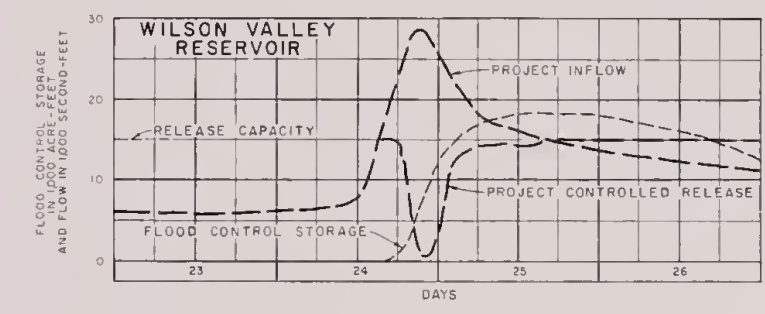
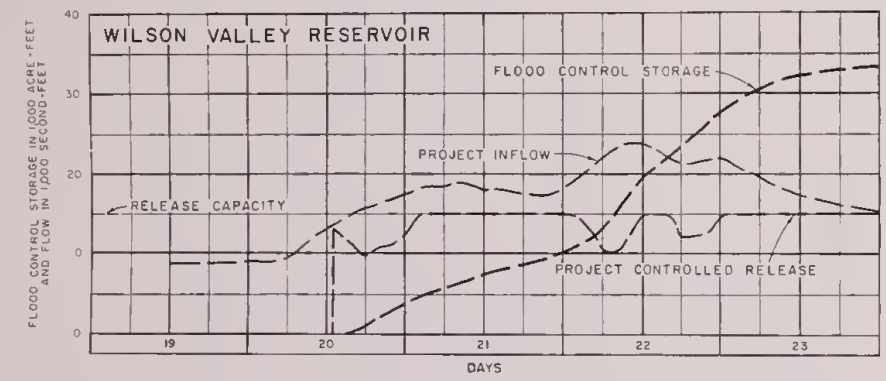
STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
DIVISION OF RESOURCES PLANNING
CLEAR LAKE-CACHE CREEK
BASIN INVESTIGATION
BROOKS DAM
ON CACHE CREEK



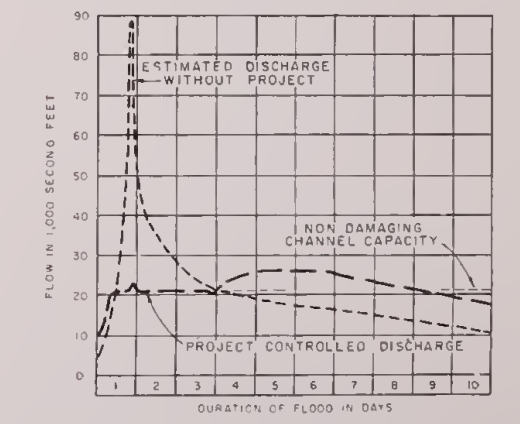
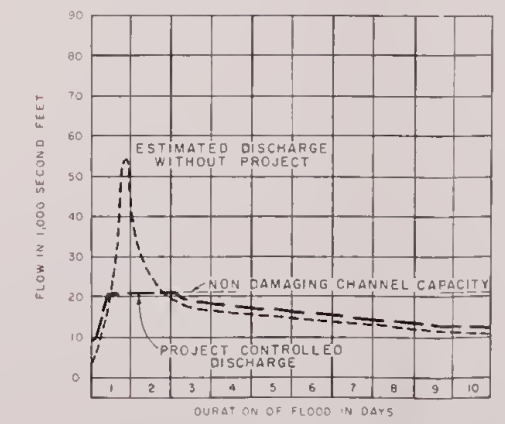
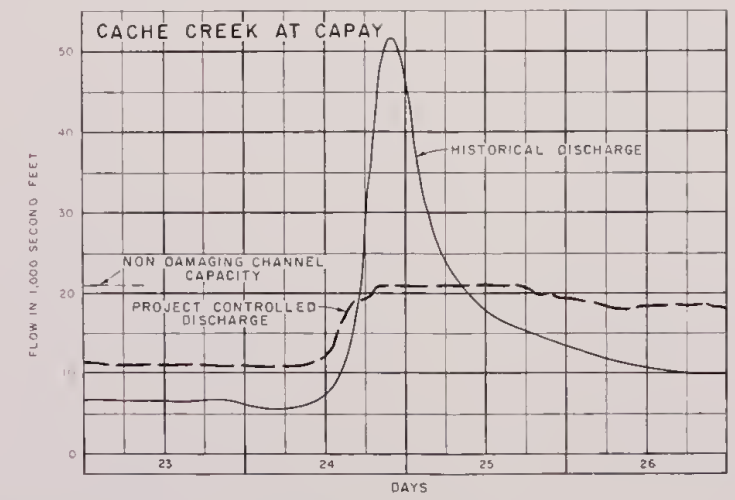
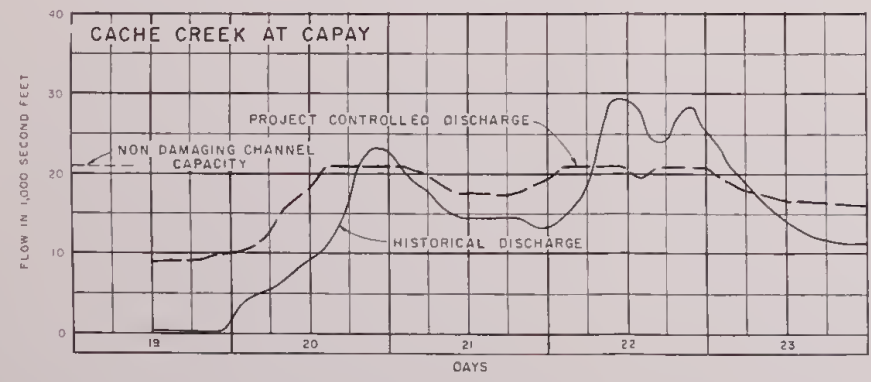
TITLE SHEET
DEPARTMENT OF WATER RESOURCES
F. REED, CHIEF PLANNING
CLEAR LAKE-CACHE CREEK
BASIN INVESTIGATION
CLEAR LAKE
OUTLET ENLARGEMENT
1960



FLOOD CONTROL OPERATION OF CLEAR LAKE



FLOOD CONTROL OPERATION OF WILSON VALLEY RESERVOIR

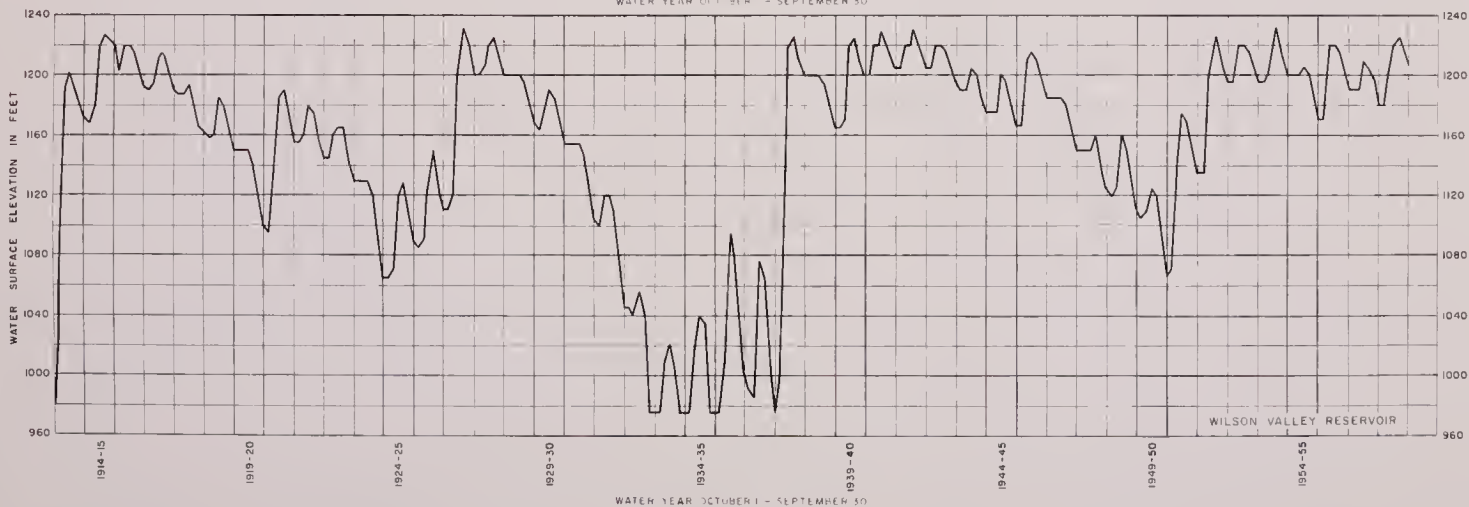
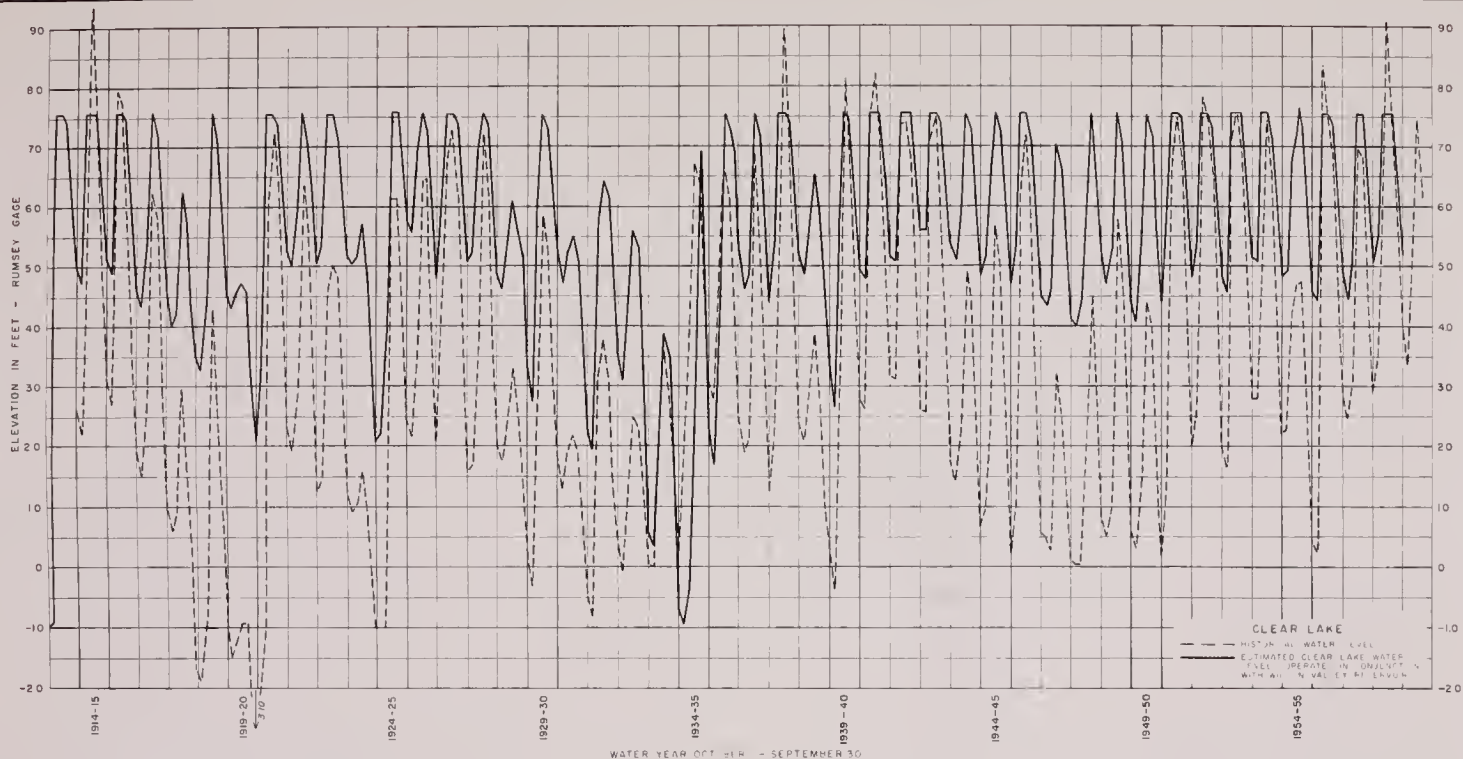


FLOOD CONTROL OPERATION OF CACHE CREEK AT CAPAY
1 IN 100 YEAR FLOOD
1 IN 1000 YEAR FLOOD

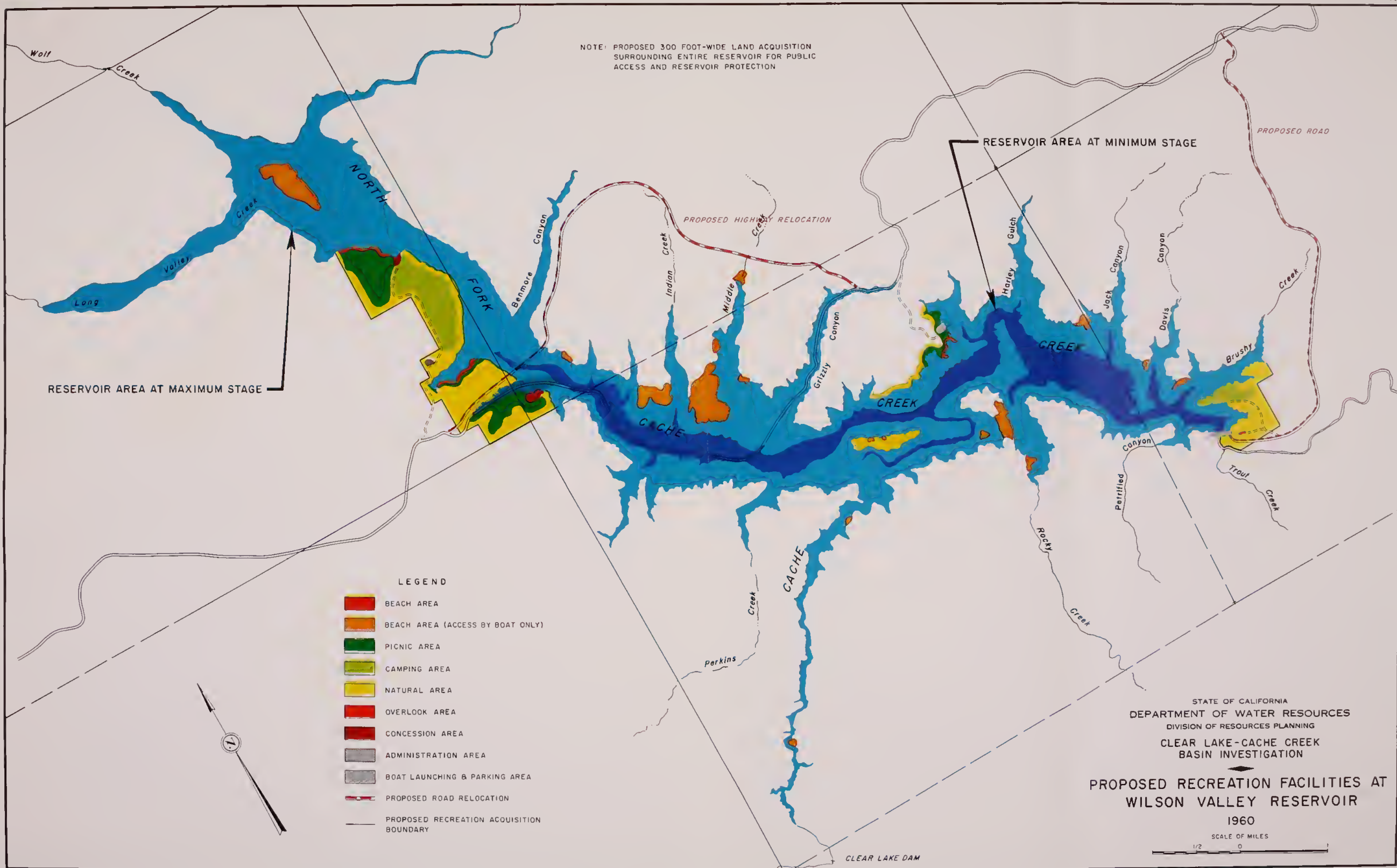
FEBRUARY 1956 FLOOD

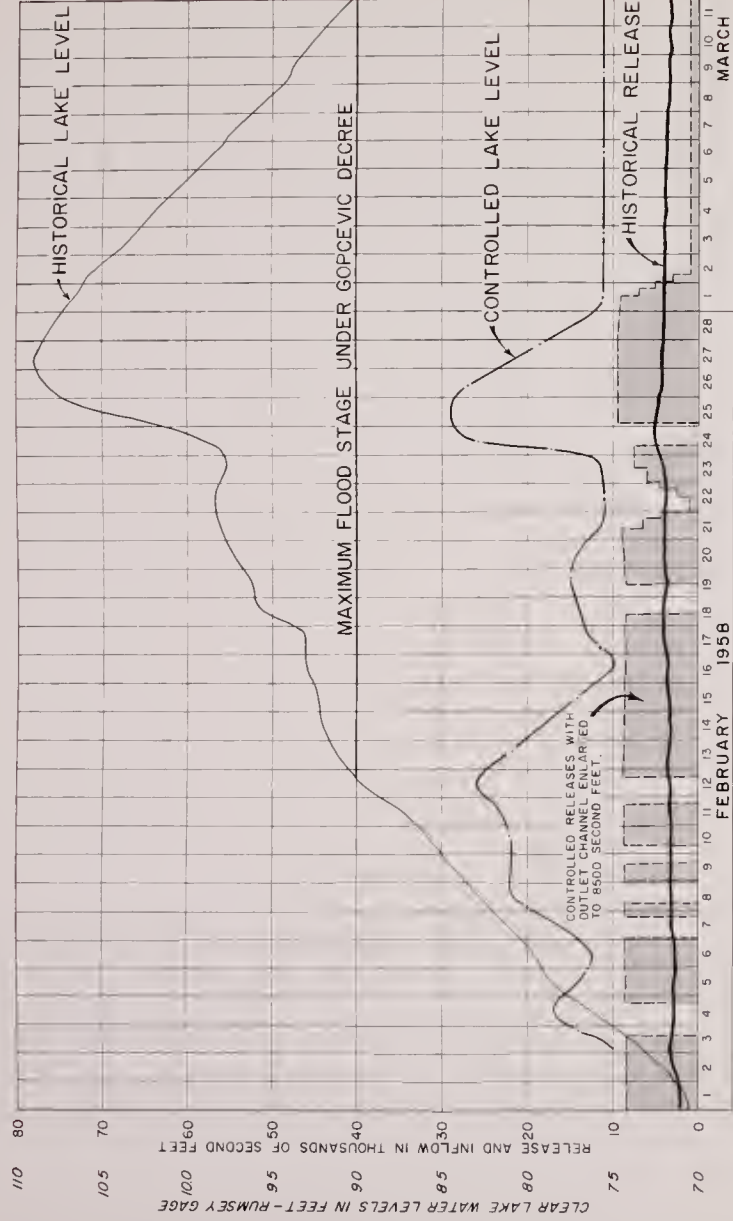
FEBRUARY 1958 FLOOD

WILSON VALLEY PROJECT FLOOD CONTROL OPERATION
FOR FEBRUARY 1956, FEBRUARY 1958, ESTIMATED 1 IN 100 YEAR AND ESTIMATED 1 IN 1000 YEAR FLOODS

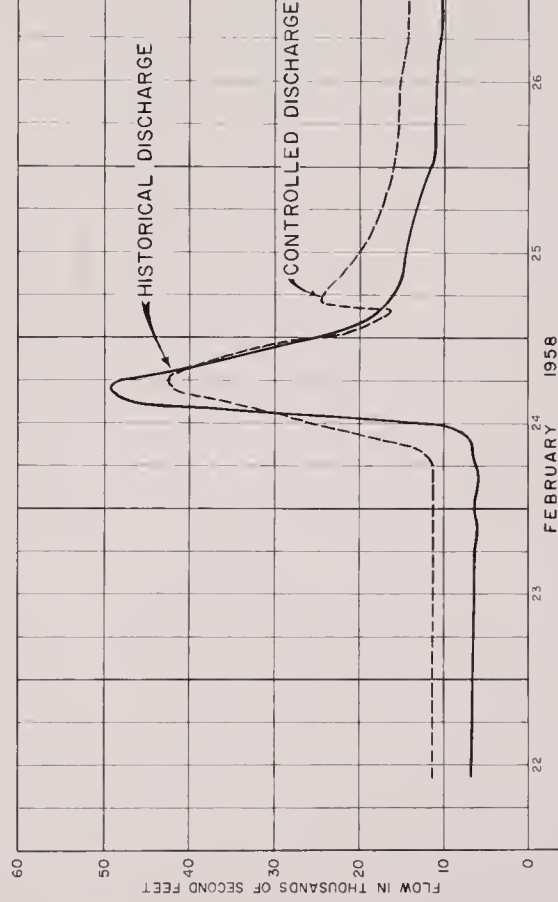


WATER LEVELS AT CLEAR LAKE AND WILSON VALLEY RESERVOIR





HISTORICAL AND CONTROLLED CLEAR LAKE WATER LEVELS
AND
RELEASES TO CACHE CREEK



HISTORICAL AND CONTROLLED DISCHARGE
OF CACHE CREEK AT RUMSEY

FLOOD OPERATION OF CLEAR LAKE AND CACHE CREEK
FLOOD OF FEBRUARY-MARCH 1958
WITH ENLARGED OUTLET CHANNEL-WITHOUT WILSON VALLEY RESERVOIR

